~~7898~~

~~7898~~
S/E.

262

कुहलकाणा।

BY THE SAME AUTHOR

CONTEMPORARY SCHOOLS OF PSYCHOLOGY

A.T
220 400

PSYCHOLOGY

BY

ROBERT S. WOODWORTH

PROFESSOR OF PSYCHOLOGY
IN COLUMBIA UNIVERSITY

Edl
406

~~406~~

GOVT NORMAL
HOOGHLY
SCHOOL

7828

TENTH EDITION, REVISED

METHUEN & CO. LTD. *LONDON*
36 Essex Street W.C.

29.7.93
7182

150
WOO

First Published in Great Britain	*March 16th*	*1922*
Second Edition	*February*	*1923*
Third Edition	*November*	*1923*
Fourth Edition	*March*	*1924*
Fifth Edition	*February*	*1925*
Sixth Edition	*February*	*1926*
Seventh Edition	*October*	*1927*
Eighth Edition, Revised	*April*	*1930*
Ninth Edition	*October*	*1932*
Tenth Edition, Revised		*1935*

PRINTED IN GREAT BRITAIN

PREFACE TO THE TENTH EDITION

In accord with the laudable tendency of the times, the author has striven to present his evidence more explicitly than before, and reference to sources has largely taken the place of citation of general texts. The omission of not a few statements which were made in previous editions does not in every case imply retraction. In order not to lengthen the text, room had to be made for the desirable new material by omitting what could be spared, especially superfluous theoretical discussion and expression of opinion. The new order of chapters is believed to be practical from the student's or reader's point of view.

R. S. W.

Columbia University
April, 1934

CONTENTS

CHAPTER PAGE

I. THE AIM OF PSYCHOLOGY 3
Individual and Environment — Activities of the Individual — Interaction between Individual and Environment — Stimulus and Response — The Stimulus-Response Formula — Orientation, Adjustment or Set — Factors in the Individual which Influence his Response to a Stimulus — Some General Principles of Psychology

II. THE METHODS OF PSYCHOLOGY 16
The Experimental Method 18
A Classical Experiment — Psychological Experiments — Control of Conditions — Difficulties in Psychological Experimentation
The Genetic Method 22
Types of Observation 25
Behavior Data — Introspective Data — Physiological Data
The Terminology of Psychology 29

III. INDIVIDUAL DIFFERENCES 31
Type Theories — Psychological Tests
The Distribution Curve 35
Other Manual Tests — No Bimodal Curves such as are Demanded by the Type Theory — How to Measure a Distribution — How to Locate the Individual in the Group
Correlation 40
The Correlation Diagram — Correlation of Different Manual Abilities — The Correlation Coefficient — Correlations of Various Abilities — Uses of the Correlation Coefficient — Correlation as a Method of Psychology — Significance of Individual Differences

CHAPTER ✓ PAGE
IV. INTELLIGENCE 49
The Measurement of Intelligence 50
The Binet Tests — The Intelligence Quotient — Performance Tests — Group Tests — Achievement Tests
Results Obtained by Use of the Intelligence Tests .. 59
The Distribution of Intelligence in the Population — Constancy of the Intelligence Quotient
How Long Intelligence Continues to Develop 64
Intelligence and Success 68
Intelligence and Scholastic Success — Intelligence and Genius — Feeblemindedness — Delinquency — Intelligence and Occupation — Intelligence in Different Races — Geographical Differences in Intelligence
An Analysis of Intelligence 80
Evidence from the Test Materials — Evidence from the Test Procedure — Evidence from Correlations — Is Intelligence a Single Ability or a Sum of Abilities?
✓
V. PERSONALITY 87
Describing Personality 88
Yes-No Classification of Individuals — Dimensions of Personality — Profiles
Personality Measurement 90
Performance Tests in Personality — Rating Scales — The Tally Questionnaire
Introversion-Extroversion 96
Is Introversion-Extroversion a Single Dimension? — No Bimodality Here — Relation of Introversion-Extroversion to other Traits — Body Build and Personality
How Consistent is the Individual in his Personality Traits? 100
Inconsistency in the Honest-Dishonest Dimension — What is Consistency? — Multiple Personality
VI. FACTORS IN PERSONALITY 108
The Blood Stream as the Chemical Integrator of the Organism

CHAPTER PAGE
The Endocrine Glands 110
Hormones — The Thyroid Gland — The Parathyroids — The Adrenal Glands — The Pituitary Gland — The Gonads — The Interdependence of the Several Endocrine Glands
Social Factors in Personality 122
Codes and Roles — The Role of the Child in the Home — Treatment of Personality Difficulties — The Role of the Child in the Gang — Acquiring the Group Code — Adopting the "Style" of the Group
Interaction of the Internal and External Factors in Developing the Personality 130
The Continuity of Personality Illustrated by a Case History

VII. HEREDITY AND ENVIRONMENT 135
Origin and Early Development of the Individual ... 136
Chromosomes and Genes — Environmental Factors in Development — Development is the Product, not the Sum, of Heredity and Environment — No Native Traits, and yet Native Differences
Experiments on Heredity and Environment 141
Hybrids Prove the Importance of Heredity in Individual Differences — Monsters Prove the Importance of Environment in Causing Individual Differences
How Differences in Intelligence are Caused 143
The Differing Heredity of Siblings — Identical Twins are the Only Exception — Identical Twins Reared Apart — The Differing Environment of Siblings — Orphanage Children — Evidence from Foster Children
Sex Differences 151
Sex Differences in Test Results
How Uniformity of Behavior is Produced 154
Compensating or Standardizing Influences

VIII. THE DEVELOPMENT OF THE INDIVIDUAL THROUGH MATURATION AND THROUGH ACTIVITY 158
Maturation 159
The Graft Experiment — Differentiation

CHAPTER PAGE
Growth through Activity 163
    Evidence for Muscle Growth Resulting from Activity — The Two Processes Contrasted
Development of the Individual's Activity 166
    Growth Curves — Prenatal Activity — The Change at Birth — The Development of Locomotion — Voice and Speech — Puberty and Sex Maturity — Social Development — Development of Intelligence
Conclusions from the Chapter 177

IX. THE NERVOUS SYSTEM 180
The Nerves 180
    Nerve Fibers — The Nerve Current — "All or None" in Nerve Fiber Activity — The Nervous System Compared with a Telephone System
The Nerve Center 185
The Cellular Structure of the Nervous System 187
    The Synapse — Inferences from Brain Structure to Brain Function
Localized and Unlocalized Brain Functions 197
    Methods of Localization — Motor and Sensory Areas — The Search for Higher Centers — Loss of Ability Dependent on Amount of Cortex Removed
The Visual Area 202
    Fiber Tracing — Varieties of Blindness — Finer Localization in the Area Striata — Effect of Stimulating the Visual Area — Psychological Experiments on the Occipital Lobe — Other Sensory Areas of the Cortex
The Motor Area 208
The Association Areas or Integrating Areas 212
    Aphasia — Apraxia — Agnosia
The Reflex Arc 213
    1. Multiple Nerve Paths — 2. Converging Paths — 3. Branching Paths — 4. Facilitation and Inhibition — 5. Continued Activity — 6. Larger Movements not Compounds of the Local Reflexes
Maturation and Exercise in the Development of the Nervous System 218

CHAPTER PAGE
X. LEARNING 223
Learned and Unlearned Activities — Definition — Learning a Fruitful Field for Experiment — The Value of Animal Experiments in the Study of Learning
Place Learning 226
The White Rat in the Maze — A Path rather than a Chain of Movements is Learned — Direction Learned, rather than a Fixed Path — The Locality Learned — Short Cuts — Learning to Shift Paths at a Signal — The Delayed Reaction Experiment — Place-Set and Goal-Set — Situation-Set or Adaptation — Negative Adaptation — Maze Learning by Human Beings
Tool Learning 238
The Cat in the Puzzle-Box — Learning by Trial and Error — Human Trial and Error Learning Demonstrated in Mirror Drawing — The Puzzle Experiment with Human Subjects — Learning by " Insight " in Chimpanzees — The Insight Experiment with Young Children
The Learning of Complex Activities 245
Higher Units of Performance — Practice does not Necessarily Make Perfect
The Conditioned Reflex 249
Extinction or Wearing Out of a Conditioned Reflex — Narrowing the Range of Stimuli that Arouse a Certain Conditioned Response — Effect of Distracting Stimuli — Precautions Necessary for the Establishment of a Conditioned Reflex — Conditioned Fear Responses — Other Conditioned Responses — Different Conceptions of the Conditioned Response
Essentials of Learning 256
Association by Contiguity — Repetition — Reward and Punishment — Pattern Forming

XI. MEMORY 261
Division of the Subject
Memorizing, or Intentional Learning 262
The Immediate Memory Span — Memorizing of

CHAPTER PAGE

Longer Lessons — Different Types of Memorizing

Economy in Memorizing 266

The Value of Recitation in Memorizing — Spaced and Unspaced Repetition — Whole versus Part Learning

Unintentional Learning 271

The Fixation or Consolidation of What has been Learned 273

Shock Amnesia — Retroactive Inhibition — Perseveration — The Tendency of Interrupted Activities to Perseverate — The Effect of Reward and Punishment on Fixation

Retention 277

The Retention Curve — Slow Forgetting during Sleep — The Cause of Forgetting — How to Avoid Forgetting — How to Forget

Recall 283

Interference in Recall — Partial Recall — Recall of Childhood Experiences — Memory Images — The Primary Memory Image — Eidetic Images — Hallucinations — Synesthesia — Recall as a Response to a Stimulus or Cue

Recognition 290

Direct and Indirect Recognition — Partial Recognition — Errors of Recognition — Disorders of Recognition — Recognition Compared with Recall

Memory Training 294

XII. MOTIVATION 299

Motive and Stimulus — A Whole Activity Motivates its Component Part Activities

Animal Drives 301

Measurement of Drives

Unlearned Motives, Formerly Called Instincts 305

Instinct — Organic Needs — The Sex Motive — The Maternal Motive or Mother Love — The Escape Motive — Shrinking from Injury — Fear — Fighting — Anger — Exploration — Manipulation — Social Motives — The Mastery or Self-Assertive Motive — Likes and Dislikes — Un-

CHAPTER PAGE

learned Motives are not the Only Springs of Action
Conflict of Motives 315
The State of Indecision — The Process of Decision — Does the Decision Always Follow the Stronger Motive — What Becomes of the Rejected Motives
Unconscious Motives 319
Effort 322
A Weight-Lifting Experiment — A Distraction Experiment
Purposive Activity 324
Prepared Action — The Preparatory Set or Adjustment — Preparatory Reactions — Special Characteristics of Purposive Activity
Will 329
Abulia — How to Get Action from Yourself — Getting Action from Other People

XIII. FEELING AND EMOTION 334
The Feelings 334
Wundt's Three Dimensions of Feeling — Feeling Distinguished from Overt Action — Feeling Distinguished from Observation of Facts — Feeling Usually Dominated by the Life of Facts and Acts
Emotion 338
How Emotions are Defined and Distinguished One from Another — How Emotions are Revealed — Expressive Movements — Learning to Control Emotional Expression — How Expressive is the Facial Language of Emotion? — Unposed Facial Expression — Vocal Expression of Emotion — Breathing and Heart Beat in Emotion — Other Signs of Emotion
Organic States in Emotion 347
The Autonomic Nerves — The Organic State in Anger — The Sympathetic-Adrenal Organic State as a Useful Preparatory Reaction — Organic States in Other Emotions — Emotions without Known Organic States — Moods
Development of the Emotional Life 353
Sentiments

CHAPTER PAGE
Theory of the Emotions 354
The James-Lange Theory of the Emotions — Evidence for and against the James-Lange Theory

XIV. THE SENSE OF SIGHT: VISUAL SENSATION AND PERCEPTION 360
What Do We See? — Sensation and Perception
Visual Sensation 362
The Eye — The Visual Receptors — Rod and Cone Vision; Adaptation of the Retina to Dim and Strong Light — Stimulus and Sensation in the Sense of Sight — Color Mixing — Elementary, Primary and Salient Color-Tones — Color Blindness — Theory of Color Vision — After-Images — Visual Contrast — The Eye as a Space and Form Sense
Visual Perception 376
Perception of Object Colors — What Object Colors are, Physically — Taking Account of the Illumination — The Set for Illumination — Visual Perception of Object Size and Shape — Eye Movements — Binocular Vision — Seeing Distance or the Third Dimension — Erect Vision in Spite of the Inversion of the Retinal Picture — Seeing Movement

XV. THE OTHER SENSES 389
Problems in the Study of the Senses — The Sense Organs in General — Mechanism of a Sense Organ
The Skin Senses 391
The Elementary Stimuli of the Skin Senses — The Skin Receptors
The Muscle Sense 395
Organic Sensation 397
The Sense of Taste 397
The Sense of Smell 400
The Sense of Hearing 401
The Sound-Receiving Apparatus of the Ear — Auditory Sensations and their Stimuli — Combinations of Tones — Timbre — Speech Sounds

CHAPTER PAGE

— The Elementary Auditory Sensations — Localization of Sounds
The Sense of Head Position and Movement 412
Perception of Objects by the Non-Visual Senses

XVI. OBSERVATION 418
Attention 418
Attending as a Set or Readiness — Attending as a Motor Adjustment — Attention as the Vivid Center of an Experience
Selectivity 421
Factors of Advantage in Attracting Attention — Factors of Advantage in Perception — Figure and Ground
The Law of Shifting 431
Shifting Perception
Sustained Attention 435
Development of Attention — Distraction — Overcoming Distractions — Doing Two Things at Once
Limitations and Errors of Observation 440
The Span of Apprehension — Constant and Variable Errors of Observation — Accuracy of Perception
Illusions 446
1. The False Object has the Advantage of Familiarity — 2. The False Object has the Advantage of Preparatory Set — 3. The False Object has the Advantage of Total Impression
Varieties of Observation 451
Signs and Meanings — Social Perception — Esthetic Perception

XVII. THINKING 457
Free Association 458
Revery — The Free Association Test
Controlled Association 461
Set or Preparation in Controlled Association — Mental Work of the Controlled Association Type
Reasoning 464
Reasoning Culminates in Inference — Difficulties in Reasoning: the Exploratory Stage — Psy-

CHAPTER PAGE

chology and Logic; the Syllogism — Difficulties in Syllogistic Reasoning — Overcoming the Difficulties of Inference — Overcoming Linguistic Difficulties in Reasoning — Motivation of Reasoning
Thought and Language 475
Thought and the Muscles
Concepts and their Development 479
Development of Concepts in the Little Child — Further Development of the Child's Concepts — Egocentric and Objective Concepts — Generalization of Concepts — Analysis and Definition — The Concept-Forming Experiment

XVIII. IMAGINATION 488
Imaginative Play 489
Beginnings of Imagination in the Child — Playthings — The Play Response — The Play Motives — Empathy — Play as Self-Motivating Activity
Daydreams 495
Mastery Daydreams — Other Motives in Daydreams — Worry — Use and Abuse of Daydreams
Dreams 500
Seeming Reality of the Dream — The Stimulus to which the Dream Responds — Motivation of Dreams — Freud's Theory of Dreams — Objections to Freud's Theory
Autistic Thinking 507
Invention and Criticism 509
The Enjoyment of Imaginative Art 511
Motivation of Novel-Reading — The Appeal of Art is Partly Emotional — Art Makes also an Intellectual Appeal — Empathy in Art Enjoyment
The Psychology of Inventive Production 515
Framework and Filling — Stages in Creative Thought — The Social Factor in Invention — Schools of Art — Schools of Psychology

QUESTIONS 523

INDEX 537

PSYCHOLOGY

A/T 220 6d 190

GOVT NORMAL SCHOOL HOOGHLY

CHAPTER I

THE AIM OF PSYCHOLOGY

The science of human behavior is really a group of sciences. On one side we find physiology studying the operation of the numerous organs and cells within the organism, and at the other extreme we find the social sciences studying nations and groups of men. There is need for some middle science that shall focus its attention upon the *individual*. That middle science is psychology. Psychology studies the activities of the individual throughout the life span, it compares child and adult, the normal and the abnormal, the human and the animal. It notes the differences between one individual and another, but is still more interested in the general laws of learning, thinking and emotion, for example, in respect to which individuals are alike. Psychology can be defined as the *science of the activities of the individual*.

Individual and environment. Our definition contains two terms which deserve some attention even though their meaning may seem obvious — the terms "individual" and "activity." The human individual originates as a fertilized ovum, grows in the mother's womb, is born at the life age of nine months, and passes through the stages of babyhood, childhood, youth, adulthood and old age to death. During this life history he remains the same identical individual in spite of many changes.

The individual is relatively separate from the rest of the world. The surface of his skin divides the world into two parts, individual and environment. The environment is always impinging upon the individual and the individual is always resisting the forces of the environment. If he goes into the water he does not dissolve. In hot or cold weather he maintains his own body temperature, and in many other ways resists the environment.

The individual's separation from the environment is, to be sure, only relative. His activities require the use of fuel and oxygen from the environment. He takes in his fuel as food, stores it in his body for a time and consumes and oxidizes it in his activities. Thus his life and activity form part of the process of nature. He *participates* in what is going on in the world about him, and all his doings are concerned directly or indirectly with the environment.

The human individual's environment is socialized to an astonishing degree. The child is born into a social group which provides for his needs and which seeks to control his actions (meeting with considerable resistance from him), and he grows up in the use of the language and customs and in short of the "culture" of his group. Even the inanimate objects with which he has most to do — toys, tools, clothes, houses, streets — have been manufactured by men and are far different from the objects of wild nature. The animals and plants he plays with have been domesticated and are part of the "material culture" of the group. The environmental activities in which he participates are apt to be humanized activities.

In defining psychology as the science of the individual's activities, then, we do not mean that the individual should be studied in isolation. He must be seen in his environment, and his activities must be seen as participations in more inclusive natural and social processes. We might mention the environment in our definition, and say that psychology is the science of the activities of the individual in relation to his environment.

Activities of the individual. The word "activity" is used here in a very broad sense. It includes not only motor activities like walking and speaking, but also cognitive activities like thinking and seeing, and emotional activities like laughing and crying, and feeling happy or sad. These last may seem to the individual himself to be passive states, yet they are activities, for they depend on the life of the organism. Any manifestation of life can be called an activity. No matter how passive an individual may seem to himself in watching a game or listening to music, he is really performing an activity.

Interaction between individual and environment. The environment is constantly doing things to the individual and the individual is constantly doing things to the environment. Environmental processes strike the individual, the individual's activity is changed in consequence, the result of this change in the individual's activity is some change in the environment which thereupon affects the individual and causes his activity to change again. This interaction goes on continually.

Let us for convenience use the letter O to represent the organism or individual, and the letter W to represent the world or environment. Then the formula,

$$W - O - W$$

shows the individual acted on by the environment (W — O) and acting on the environment (O — W). But how does the environment "do things" to the individual, and how does he "do things" to the environment? To naïve common sense, it seems that there is no real problem here. If the individual wishes to change the position of a chair he simply pushes it away. If he wishes to attract some one's attention he simply calls to him. He of course uses his hands in pushing and his mouth in calling. Just a little physiology is enough to reveal the muscles moving the hands and vocal organs, the nerves activating the muscles, and the brain activating the nerves. The individual is scarcely aware of his muscles, still less of his brain and nerves. He is aware of the acts he is performing, that is to say, of the changes which he is producing in the environment.

The muscles are called *effectors,* because they produce environmental effects. The only other effectors possessed by the human being are the glands, such as the salivary glands which moisten whatever is in the mouth. The light organ of the firefly and the electric organ of certain fishes are to be classed as effectors.

In a broad sense, then, the individual acts on the environment and produces changes there, while in a narrower sense all he can do is to activate his effectors. By activating his effectors he participates in what is happening in the environment.

Having thus gained some idea of how O does things to W, let us turn to the other half of our problem. How does W act on O? How does the individual become aware of the objects and happenings about him? Here again the problem seems at first thought too simple to merit consideration. If the individual is not blind and deaf, he "naturally" knows what is going on around him; he sees an object, hears a person calling. Seeing and hearing seem to reach out into the environment and lay hold in some way of the objects that are out there. But how the individual by simply looking in a certain direction can reach out ten feet or a mile and "lay hold" of distant objects remained a mystery till physics had discovered the nature of light and sound. Light and sound radiate from an object and some of the radiation enters the eye or ear, and only thus is the individual enabled to see or hear. Instead of reaching out into the environment he simply receives these bits of radiation. His skin also receives heat and pressure from the environment, and his nose and mouth receive odorous and sapid particles. He receives these environmental forces by aid of specialized sense organs or *receptors.*

Stimulus and response. These forces or motions which reach the organism from the environment and which enter the receptors are called *stimuli.* A stimulus, literally a goad or pointed stick, is anything that arouses the organism or any of its parts to activity. Light is a stimulus to the eye, sound to the ear. A *response* is any activity that is awakened or aroused by a stimulus. The goad does not push the ox forward but causes him to walk faster. A stimulus does not force the organism this way or that, but starts up an activity of the organism. Or, since the organism is continually active, what the stimulus does is to initiate a *change* in the organism's activity, it may be an increase or a decrease of activity or a shift from one activity to another.

Though stimuli come very largely from the environment, some arise within the organism. Aches and pains, hunger and thirst are sensations aroused by internal stimuli.

The stimulus-response formula. To symbolize the fact that the activity of the individual is aroused and changed by stimuli, a little scheme or diagram is often employed:

$$S - R, \text{ or } S \rightarrow R,$$

in which S stands for the stimulus and R for the response, so that the formula reads, "A stimulus arouses a response," or, "The response is aroused by a stimulus."

Sometimes this formula is taken to mean that you can predict the response if you know the stimulus, and that to secure a certain response you need only to apply the right stimulus. But there is something more you have to know. Different individuals respond differently to the same stimulus. If you hear some creature stirring in a hedge and coo to it, it will probably fly away if it is a bird and rush toward you if it is a dog. If it is a human being, it would be hard to predict the response without knowing the age, sex and training of the individual, what he was doing and in what mood he happened to be at that moment. You must know your O. So a more adequate formula is:

$$S - O - R, \text{ or } S \rightarrow O \rightarrow R,$$

to be read that the stimulus, acting on the individual, elicits the response, or that the individual changes his activity in response to a stimulus.

Even yet we have not fitted our individual into his environment. The stimuli come *from* the environment, and the responses go *towards* the environment. We need to introduce W, the environment, into our formula, and we need to introduce it at both ends, once as the source of the stimulus and again as the destination of the response. Thus expanded the formula becomes:

$$W — S — O — R — W,$$

to be read that stimuli from the environment arouse the individual to make responsive movements which change the environment.

The straight-line formula just given rather suggests that an activity consists of a single stimulus and a single response. More typical is the continued activity, in which the environmental change produced by the first response gives occasion for a second response and so on for a long series of interactions between O and W, as in walking or talking or driving a nail. To represent this typical case we can bend the straight line of the formula around into a circle so as to have the diagram:

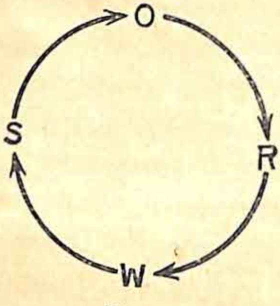


FIG. 1

This reads that the individual and the environment are continually interacting, the environment acting on the individual by stimuli, and the individual acting on the environment by his responses.

The main defect of this diagram is that it suggests a spinning top or pinwheel which revolves without going anywhere. In the case of the organism and the environment there is some progress, for not only does O's response change W, as we have said, but also it changes O himself. It may leave him fatigued or excited; it may teach him something. To take account of these changes we might use the following diagram:

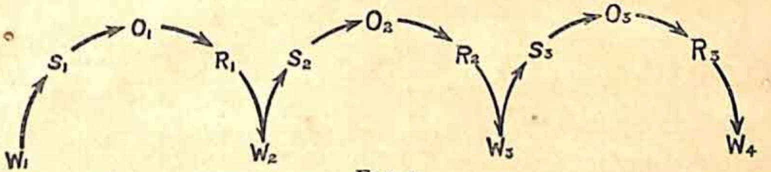


FIG. 2

The straight-line diagram, W — S — O — R — W, will carry all the meaning, if one reads into it all that has been said. On the positive side, it includes the following statements:

The environment acts on the individual by stimuli.

The stimuli arouse the individual to responses characteristic of himself.

These responses change the environment.

They also change the individual himself.

Equally important are the negative implications of the diagram. They are:

The individual, though participating in environmental processes, is relatively separate from the environment.

The objects of the environment, though sending out stimuli which the individual receives, are not themselves stimuli.

The responses of the individual, though producing changes in the environment, are not those changes.

Orientation, adjustment or set. There is one remarkable fact not yet taken up into our diagram nor sufficiently emphasized in the preceding discussions. The individual is typically in much more intimate relations with his environment than is implied by the statement that he receives stimuli from the environment and responds by muscular contractions which affect the environment. He seems not only to be getting light rays and sound waves and to be making muscular movements, but also to see people and to hear things and to participate actively in the situation. Where shall we find room for this sense of the real, total, developing situation? We can find it only in O. Part of his response to stimuli consists in *registering the objective situation* which they indicate.

Suppose O is on a journey. He comes to a strange town, looks around the place, receiving stimuli, and registering the lay-out of the streets, the interesting buildings, the appearance of the people. He goes to his hotel, sleeps through the night and on wakening the next morning may for an instant not know where he is. But it soon comes back to him and he is oriented. He has the town "in his head" and can go out and find his way around. This "town in his head" is not a mere jumble of impressions but a coherent framework built up by aid of the stimuli he has received in walking about the town.

Our individual may have something more "in his head." He may have some business to transact in that town. What is "in his head" amounts to a plan of action in a certain environment. As he now goes out into the town, the new stimuli that he receives are registered in the framework that he already possesses and in relation to the business that he has on hand. He is not a mere receiver of momentary stimuli and a maker of casual responses to these stimuli, but his responses are parts of the business in which he is engaged.

We need some word to express the fact that the individual is very apt to be oriented in his environment and engaged in some activity related to the environment. We should use some rather neutral word that carries as few implications as possible, for we cannot pretend at the outset to know *how* the individual registers the environment nor how he directs his activity towards a definite result. We want a word that could be applied not only to human behavior but also to that of any animal that is clearly oriented in his environment and aiming at a goal. *Adjustment* is often used, and a still simpler word that will serve fairly well is *set,* used both as a noun and as a verb in much the same sense as when we speak of setting the clock or of the "ready — set — go" in starting a race. Imagine a machine that can be "set" for doing one or another sort of work, and you have the idea. A "set" is something temporary, something that changes with the environment and with the job on hand. Yet it is more than momentary. We may speak of a *situation-set,* meaning that the individual has registered a particular environment and is oriented in it; and we may speak of a *goal-set* when the individual's activity is directed towards a certain result.

When O is set for a certain environment and for action in that environment, we may symbolize him by Ow, and incorporate the symbol in our formula, as follows:

$$W — S — Ow — R — W,$$

which means that stimuli from the environment act upon O who is set for the environment and arouse responses directed towards some environmental result.

This formula no doubt outlines some of the main facts of psychology, but what it principally does is to indicate one of the main *problems* of psychology — the problem of how all this can possibly take place. How does it come about that the individual, shut in as he is, receiving only stimuli and making only muscular and glandular responses, nevertheless registers the environment and participates effectively in what goes on in the environment? That is the problem; the answer cannot be given at this point and in fact cannot be completely given by anyone as yet; for it is an intricate problem, and only partially solved.

Another main problem of psychology is that of development and change of the individual. The individual grows and learns, but the question is; How? The problem of change in the individual is related to the stimulus-response problem in a way that will become clear in the next few paragraphs.

Factors in the individual which influence his response to a stimulus. It has been said already that the response depends on the individual as well as on the stimulus. The same stimulus may arouse different responses from different individuals or from the same individual at different times. Now in what respects do individuals differ or does the same individual differ from one time to another?

The difference may be one of *structure*. The differing structure of the dog and the bird is an important factor in making them give different responses to a sudden noise. The grown man has larger muscles than the child, and this structural difference makes their responses differ. The enormously complicated structure of the brain differs from one individual to another, and changes with age, and no doubt is a very important factor in producing differences of behavior.

The structure of an individual at any time is the outcome of his development up to that time, and this previous development has consisted partly in what we call the natural process of growth and partly in the process of learning. Both natural growth and learning depend on the hereditary or native constitution of the individual, and on his responses to the stimuli received from the environment up to the time in question.

Though structure changes, it is relatively permanent. It is the stable factor in the individual's behavior. A more changeable and temporary factor is the present *condition* of the individual. At one time the individual is tired or sleepy or actually asleep, while a little later he is fresh and wide-awake. These are differences of condition. Intoxication and fever and hunger and thirst are probably chemical conditions of the organism. Then we have the moods and emotional conditions, excitement, languor, depression, anger, cheerfulness. Certainly the condition of the organism is an important factor in determining the response made to a stimulus.

Another temporary factor in determining the response is what we may describe as the *activity in progress*. The response to any stimulus differs according to the activity in which the individual is engaged at the moment. While deeply absorbed in reading he fails to notice remarks from other persons which would otherwise bring an animated response. On the other hand if he is looking for a lost ball his eye catches little glints of white in the grass that would usually make no impression on him. Thus stimuli that are in line with his activity-in-progress get a quick response, while stimuli that are out of line may get no response at all.

The "set" of which we spoke is also a very potent temporary factor; but a set is an activity and can be included under the general head of activity in progress.

All the factors in determining a response can be summed up in a little table.

The response depends on:

I. the present stimulus
II. the individual, and thus upon
    1. his structure, dependent on
        a. his heredity
        b. his previous environment
    2. his present condition
        a. chemical
        b. emotional
    3. his activity in progress, including
        a. his situation-set
        b. his goal-set

Some general principles of psychology. Even in this preliminary view we have glimpsed a few general facts which deserve to be set down in definite form.

1. The first principle of psychology is contained in the definition, and is that the individual acts as a unit. Without this fundamental principle, often called the "organismic principle," it would be impossible to explain anything in psychology. But it must be admitted that we could not go far with the principle of unity alone. We should have to meet every problem by merely chanting, "One, one, one," in a sort of ritual. Just as geometry needs more than a single axiom, psychology needs more than a single fundamental principle. We have already glimpsed several others.

2. The organism is not simply "one"; it is a system of many parts, of many organs, of many, many living cells. Thus the individual's activity is complex at the same time that it is unitary.

3. The organism participates in environmental processes, while still maintaining its individuality.

4. Participation takes place only by means of stimuli received and muscular and glandular responses executed.

5. The organism becomes set or adjusted for situations and for goals.

6. One individual differs from another.

7. The same individual displays a variety of activities.

8. The individual changes in time, growing, learning, declining.

9. Far from being simply responsive to the environment, far from being simply molded by it, the individual makes demands upon the environment; he has needs, desires, goals.

10. Many of the individual's activities are "synthetic," i.e., they combine and integrate activities which were previously performed separately. This principle has been sometimes regarded as inconsistent with the organismic principle, but we

shall find that it is perfectly consistent with the organism as it is. The building up of a "situation set" from successive impressions is an example of synthetic activity.

These principles are not like the axioms of geometry. They are not self-evident. Neither are they "postulates" nor assumptions. They are generalized statements of observed facts, and we shall meet the observed facts as we proceed. The principles are stated dogmatically here at the outset simply to open a few vistas into the subject that lies before us.

CHAPTER II

THE METHODS OF PSYCHOLOGY

The easy way of psychologizing, and the "good old fashioned way," is to settle yourself comfortably in an armchair and consider what your past experience leads you to believe on any question that has come up. You have known people all your life, you have observed them and dealt with them, and it would seem that you must know a good deal of psychology already. Probably you do, but, as some one has said, we know so many things that are not so. There is no way of separating the wheat from the chaff, as long as you simply draw upon your general impressions derived from past experience.

The method of solitary reflection can be improved somewhat by discussing the question with some one else. You will probably find that his ideas do not entirely agree with your own. He may be able to convince you or you may convince him, but are you sure either way that you have reached the right answer? Even if you should discuss the matter with a group of people and put the issue to a vote, could you be sure that a majority or even a unanimous vote would give the right answer? The old practically universal belief of mankind that the earth was flat, a belief seemingly confirmed by universal experience, held sway until men began sailing around the earth. The real facts of nature have to be discovered by exploration, and this is as true of human nature as of the world of inanimate things.

Science cannot accept a general impression derived from past experience as the final answer to any question. It takes it only as a tentative answer and asks if anyone has an alternative answer to be considered. As soon as there are two or more clean-cut alternative answers to a question, science is eager to put them to the test of facts, in the hope that the facts will rule out some of the alternatives and leave one answer in possession of the field. Even then the answer reached is not necessarily final; facts later discovered may disprove it. Science will not accept any view as champion as long as there is a contesting view in the ring. A view awaiting the decision of the facts is what science calls a *hypothesis*. General impressions, derived from past experience, have the status of hypotheses, not of conclusions.

The *anecdotal method* does at least recognize the need for facts in testing out any hypothesis. When a question has arisen and two alternative answers have emerged from the discussion, one of the debaters will bring up a case to prove his point, and if he is allowed to hold the floor he may pile case on case and convince his audience — till his opponent begins to bring up the cases on the other side. The anecdotal method is at best a haphazard way of assembling the facts. It would be much better to go out and gather the facts systematically. Anecdotes of human behavior are likely to rest on imperfect observation made worse by imperfect memory. Science needs first-hand observations.

There is still another difficulty with anecdotes and with impressions from past experience. Someone tells you that he *knows* from his own past experience that bad luck comes on the 13th of the month, for he has taken pains to notice, and is sure of his facts. But has he taken note of the *negative instances*, or did only the positive instances impress him? How often does bad luck come on the 13th and how often on other days? If anyone thought it worth while to make a scientific study of luck on the 13th, he would get a diary and note down every day his good luck and his bad luck — taking care to use the same standards of good and bad throughout — and finally sum up the results over a long period of time. In this way, the memory error, the error of one-sided selection of cases, and the error of too small samples would be avoided.

THE EXPERIMENTAL METHOD

An experiment is one means of obtaining reliable observations bearing on a definite question. The experimenter has the advantage of knowing exactly where and when to look, and so is well "set" for accurate observation; and by recording his observation immediately he avoids the memory error. Besides all this, the experimenter "controls the conditions." He does not let things happen at random; in the ideal experiment he has all the factors under his control that have any influence on the

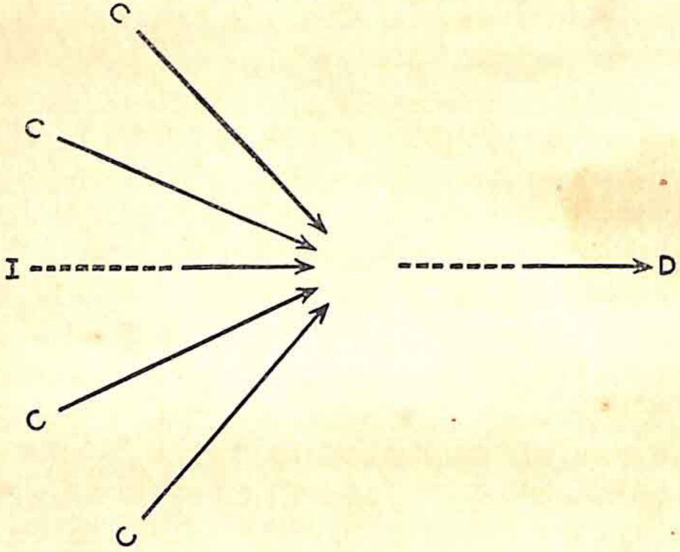


FIG. 3. — Scheme of an experiment. D is the dependent variable, the subject's "response" in a psychological experiment. The arrows converging upon the center from which D takes its start are the influences or conditions which may affect the response and have to be controlled. Those marked C are held constant throughout the experiment, whereas the one marked I is the independent variable, which is made to vary so that the resulting variation in D can be observed.

process to be observed. The result shows him what happens under certain known conditions. He varies one factor and notes what difference that makes in the result. The rule for an ideal experiment is to control all the factors or conditions, to keep all of them constant except a single one — which is then the *independent variable* — and to vary this one systematically and observe the results. The results are changes in the *dependent variable.* When he finishes his series of experiments, he knows the changes in the dependent variable which are produced by changes in the independent variable.

A classical experiment. Galileo had developed a hypothesis according to which all bodies, large or small, heavy or light, should fall toward the earth with equal speed. The older, alternative view was that heavy bodies fell faster than light, and common experience seemed to show that, certainly, feathers fell much more slowly than bullets of lead. But Galileo thought this difference might be due to the resistance of the air. He accordingly exhausted the air from a long glass tube in which he had placed, at the bottom, a bullet and a feather. He quickly inverted the air-free tube, and the two objects fell side by side. When air was admitted, of course, the bullet fell much more rapidly than the feather. The experiment is classical because (a) Galileo started with a definite question; (b) he saw how to force an answer, (c) he had the conditions under his control, and held them all constant except the amount of air in the tube, which was his independent variable, the dependent variable being the rate of fall of the two bodies.

Psychological experiments. At least two individuals participate, one as the experimenter, the other as the subject whose activities are being observed. The experimenter is often designated as E, the subject as O.[1]

---

[1] The subject in the experiment is evidently none other than the individual organism studied by psychology, so that we keep the same symbol, O, for him. This usage goes a little beyond what is customary in psychology,

The experiment is of course E's, not O's. E knows what it is all about, while O is typically kept in ignorance of the ultimate purpose of the experiment. In experiments on human subjects E usually gives *instructions* to O and assigns his *task*. When O is an animal E has to devise some substitute for the instructions.

Control of conditions. From the analysis in the previous chapter, it is clear that the conditions to be controlled lie in the environment and in O himself. To control the external situation and stimuli is a matter of laboratory technique; for example, a dark room may be necessary for a certain experiment, and a piece of apparatus for exposing an object exactly 1/10 of a second. But how control O's internal condition? Condition was analyzed into chemical condition, emotional condition, and activity in progress. The instructions are intended to control the activity in progress, and do so better than one might suppose, for O usually gives close attention to the task. The emotional condition cannot be wholly controlled, since O may be excited or worried about his task; but with continued experience in the laboratory his emotional condition tends to stabilize itself. The chemical or organic condition can be controlled to some extent by making sure that O is well, and sometimes by regulating his diet and hours of sleep.

What we called the "structure" of O also comes under the head of conditions that E needs to control. He controls them partly by selecting his subjects to meet certain specifications. He may select monkeys for a certain experiment, college sophomores for another. He knows the age and general background

---

as O, meaning "observer," has been used to designate the subject only in introspective experiments, in which the subject is required to observe his own activity. In other experiments the subject has been designated by the letter S. S is needed however as a symbol for "stimulus." No confusion can arise from extending the meaning of O to cover the subject in any experiment, even an animal experiment. O is to be thought of then as an abbreviation for "organism."

of his subjects. In addition, he may find it necessary to standardize his subjects by a period of preliminary training in the task which they have to perform.

When all is said, the psychological experimenter cannot hope to control conditions completely. He must have recourse to repeated experiments, or to experiments with large numbers of subjects, so as to iron out the chance variation that is sure to occur in the internal conditions.

The independent variable in a psychological experiment is usually some factor in the external situation and belonging under the head of S, but sometimes it belongs under the head of O, whose task may be varied. The dependent variable belongs usually if not always under R, or under the external results produced by R. The generalized question in a psychological experiment has the form: how does the individual's activity change or vary with a given variation in the situation or in the individual?

In terms of the W — S — O — R — W formula, a psychological experiment consists in controlling by laboratory technique the situation W and so the stimuli S that reach O, and in controlling O himself by instructions and otherwise, in then varying one factor in S or O, and noting the effect on R or on W, the external results of R.

Difficulties in psychological experimentation. Difficulties arise in the attempt to control conditions adequately, and especially in the attempt to vary the independent variable as widely as desirable. Though it is possible to control the emotional condition of the subject to the extent of keeping him comfortable and interested, and in a fairly constant emotional condition, it is quite another thing to take emotion as the independent variable and to induce in the subject all degrees of fear or anger or love from zero to the maximum. If you desired to study the process of creative thought, you could place the subject in favorable external conditions and give him a good

29.7.93

task to work on, but he might find it impossible at that moment to do anything specially creative, internal conditions not being favorable.

The difficulty of controlling conditions is very troublesome in attempts to study child development and the effects of heredity and environment. The experimenter will not subject a child to unfavorable conditions. He will not voluntarily give the child a diet so inadequate as to stunt the child's physical growth, in order to see whether the intelligence also is stunted. But he can try a similar experiment on animals. Suppose a question is raised in the psychologist's mind by reading of the "wolf children" said to have been found in India — children who had grown up from infancy in a wolf's den and entirely away from human influences, and who ran around on all fours and grunted and growled instead of talking. Suppose the alleged facts lead the psychologist to entertain a hypothesis alternative to our usual belief about the different behavior of wolves and men. Let him set up the hypothesis that a human child walks on two legs because he has been brought up with humans. Can he experiment by managing somehow to have a child reared by wolves, to watch the effect on the child's development? He could bring up a young wolf in a human household, treating him as nearly as possible like a human child, and see how far the wolf approximates to the behavior of the child.

THE GENETIC METHOD

When a process, such as the child's mental development, must not be interfered with drastically, the requirement of controlling the conditions cannot be fully met, and psychology has to resort to a genetic or follow-up method. The development is observed as it proceeds. When we know that something interesting is going to happen, as that the child is about ready to begin learning to talk, or that he is soon to have a baby brother or sister to whose presence in the family he must adjust himself, then we can be prepared to observe the process step by step.

Often, however, a significant development occurs that could not be anticipated. We find a genius, or an insane person, a criminal, or a "problem child" before us, and we desire to know how he came to be what he is. We are forced to adopt a substitute for the genetic method by reconstructing the individual's history as well as we can from his memory, the memories of his acquaintances, and such records as may have been preserved. This case history method has obvious disadvantages, but, as obviously, it is the only way to make a start towards answering certain important questions.

The *case history method,* up to the present time, has been employed mostly upon individuals whose behavior is abnormal in some respect. Either they have broken down mentally, or their conduct has become socially objectionable. One purpose in obtaining a case history is the practical one of helping to remedy the undesirable behavior. Suppose a boy from a good family has been caught stealing; he is taken to a clinic, where the staff of experts goes into his history from all points of view, medical, psychological and social. The experts win the boy's cooperation by their friendly spirit and make it clear to him that they are not seeking to "get something on him," but to help him by first understanding him. They know that the misconduct has causes which should be discovered; ten to one, it is not mere depravity but depends on his environment and on his own limitations. They labor to unearth his personal troubles and to trace his misconduct to its sources in his previous life.

However, the clinic does more than construct a history of the case to date. It proceeds to follow up the case, thus supplementing the case history by a genetic study. Also, in cooperation with the home and the school, the clinic tries an experiment on the boy, by way of treatment. Any treatment of such a case is experimental in some degree, for there can be no certainty of success. The case history, along with the boy's present condition, suggests some hypothesis as to the causes of the misconduct; and the experiment tests this hypothesis by so altering the conditions of the boy's life as to remove the supposed causes. If the treatment succeeds, the hypothesis is verified; but if not, some other hypothesis must be given a trial. Clinical psychology, then, uses all the methods of psychology, and while it is "applied" rather than "pure" psychology, while, that is to say, it has a practical rather than a purely scientific aim, it may be expected, in proportion as it is adequately carried out, to throw much light on behavior and development. Still more promising is the real genetic study of young children, now being undertaken with great energy; for the case history furnishes scant information on the earliest years, which may be the most important formative years of the individual's life.

While the cause of misfits and failures is certainly an important matter for study, would it not be still more desirable to trace the development of the successful people, the great people, the lovely people, the splendid people of all sorts? The difficulty is, however, that one cannot tell in advance which little child is going to become that kind of adult. And when a person has already become famous, and the psychologist suggests that he would make a fine subject for a case history, he may see no advantage to himself and may not sympathize with the psychologist's desire to study him for the advancement of science. Adults are rather sensitive about being probed, unless they have got into trouble from which the expert may release them. The result is that, up to date, our case history material is decidedly one-sided. We have to turn to biographies of the great, written usually without special psychological interest, and meager in the developmental stage of the individual's life.

The case history method has some of the defects of the method of anecdotes. It depends largely on memory of incidents that were not observed with scientific intent when they occurred, and which may have been over-interpreted. It is very liable to the error of neglecting negative cases.

TYPES OF OBSERVATION

The two methods already described, the experimental and the genetic, are general lines of attack upon psychological problems. They are two broad ways in which an investigation can be laid out. When we come down to the details of any investigation, we find particular methods of which there are a vast number. There are also three types of data, three types of facts-observed-and-recorded, which need to be distinguished. They may be called behavior data, introspective data, and physiological data.

Behavior data. A behavior record describes the subject's behavior under certain external and internal conditions. It is sometimes defined as a record of the subject's responses to certain stimuli, but this definition is inexact, since the precise stimuli acting on the subject's receptors are seldom specified and his muscular and glandular responses are seldom directly observed. Instead of describing stimuli, the record usually contents itself with stating the *objects* with which O was confronted; and instead of describing his muscular responses, the record states what he "did," i.e., what environmental effects he produced. When, for example, the subject hits at a target, its size, distance and illumination are noted in the record, and his hits on the target are noted; but no attempt is usually made to specify exactly what light was entering his eyes at every moment nor to discover the exact combination of muscles by which he executed his hitting movement. Behavior is what O does to objects under certain conditions. Behavior data are objective facts, and mostly environmental facts.

Under the head of behavior data belongs the largest share of all the facts recorded by psychologists. The time it takes a subject to perform a task may be measured with a stop watch or some more accurate instrument. The errors which the subject makes in shooting at a target or in reciting a memory lesson or in taking a test of any sort can be counted or measured. His breathing and pulse may be recorded by special instruments. A motion picture may be made of his movements and a phonograph record taken of his voice and speech, and these records may be analyzed in detail.

Behavior data record the interplay between the individual and his environment. They do not set forth directly what goes on in the individual during this interplay. The psychologist would like to know what goes on in an animal while he is learning a trick, and what goes on in a man while he is reading or loving or inventing. The psychologist can infer something of the inner process from noting how the behavior varies with variation of the conditions. He can set up hypotheses regarding the inner process and check them by placing the subject under suitable conditions. So the psychologist is not badly off if he limits himself to the use of behavior data.

Introspective data are facts reported by the subject regarding his own feelings, ideas and efforts, and regarding what he himself sees in the situation with which he is dealing. He is asked to report these facts as observed by himself during an activity of his own. He is asked to report what he experienced during the activity. He is cautioned not to attempt to explain his performance, but simply to observe and report. The subject is not supposed to be making a study of himself, but simply to be reporting for the experimenter's information such facts as he can observe during a certain performance.

One simple form of introspection is illustrated by observations of the "after-image." If anyone looks fixedly for twenty seconds at a black square and then turns his eyes upon a plain gray wall, he sees a white square on the wall. This after-image is not an environmental fact in the least; there is no physical square on the gray background; it is purely a subjective phenomenon, occurring in the subject as a phase of the activity aroused in him by the stimulus. Everyone, after a little training, can observe his own after-images, but no one can observe those of another person. It is the same way with pains; only the individual who has the toothache is in a position to observe it, but he seems to be very sure of his observation. Any sensory activity of an individual can be observed by that same individual in a perfectly direct way. In experiments on the senses, then, with human subjects, the customary procedure is to apply a known stimulus to the subject and ask him to report what he sees or hears or smells. Introspection in such experiments is the same as any ordinary observation, except that the observer understands that his senses are being tested and that therefore he should observe only what he gets directly from the given stimulus and not seek to beat the game by utilizing any indirect information that may be available. If for example his eyes are being tested, he does not try to sneak up closer to the test chart beforehand so as to know the letters he is supposed to read from a distance.

In a somewhat different sort of introspection the subject attempts, as soon as he has finished a certain performance, to review his experience during the performance and report what he can of the experience. If in an experiment on reading, the letter group

PSYCHOLOGY

is shown for a fraction of a second, and the subject reads it as "psychology," we have so far a behavior record, from which we might infer that the subject overlooked the misprint. But if he reports experiencing some strain and dissatisfaction and a messy appearance of the first part of the word, we learn from this introspective report that the misspelling did after all make some impression on him. In a longer performance, such as solving a puzzle, the subject may be able to report the steps he went through and so give a more complete picture of the process than the experimenter could get from noting his visible behavior. This second sort of introspection is distrusted by many psychologists, and undoubtedly it does make rather heavy demands on the subject, who is prone to interpret his experience instead of reporting the bare facts and who may attempt to report on details that he did not accurately observe. But results show that you can trust introspection if you do not expect too much of it. It is a mine of hypotheses that can later be tested by elaborate behavior experiments.

Physiological data. While behavior data show the interplay between the organism and the environment and while introspective data reveal something of what goes on in the organism during this interplay, it is the special province of physiology to investigate in detail what goes on in the organism. Physiology picks the organism to pieces, literally or figuratively, and seeks to find out what each organ is contributing to the life and activity of the whole. It seeks to find out what goes on in the eye during seeing, and in the larynx and other speech organs during talking; how the muscles through their tendons work the fingers in grasping an object; how the fuel of the food and the oxygen from the lungs are combined to liberate the energy of muscular activity; how the blood stream keeps every organ supplied with the necessary materials; and how that enormously complex mechanism, the brain, plays its role in integrating the activities of the indvidual, in "setting" him for his environment and enabling him to participate intelligently and effectively in what is going on in the environment. Physiology aims to do all this, but its problem is so vast that we cannot expect from it a complete picture of what goes on in the organism. Even if it could show us all the details we should still need our behavior data and introspective data to reveal the larger patterns of activity and the interplay between the organism and the environment. Psychology and physiology serve as checks upon each other and need to be fitted together, as far as possible, in order to give an adequate picture of the activities of the individual.

THE TERMINOLOGY OF PSYCHOLOGY

Since psychology has to do with activities or processes, its terms are properly verbs and adverbs. It needs one noun, *individual*, or *organism*, or the equivalent, as the subject of its verbs; and, to be sure, it needs to name any number of external objects that act upon the individual and are acted on by him; and when it dips into physiology it needs to name organs and structures. But there are a host of other nouns commonly used in psychology, names of activities and names of qualities, such as intelligence, personality, memory, imagination, thought, will, sensation, emotion, attention, perception, consciousness, behavior. All such nouns are properly verbs or adverbs, with "individual" as their subject. Much confusion and controversy would be avoided if these nouns were always thought of as verbs or adverbs.

Instead of "memory" we should properly say "remembering" or "somebody remembers," instead of "sensation" we should say "seeing," "hearing," etc., and instead of "emotion" we should say that someone feels eager or angry or afraid. But, like other learned branches, psychology finds it rather convenient to transform its verbs into nouns. Then what happens? We forget that our nouns are merely substitutes for verbs, and go hunting for the *things* denoted by the nouns — for substances, forces, faculties — but no such things exist; there are only the activities with which we started.

Intelligence, consciousness, the unconscious are like skill or speed. They are not properly even verbs; they are adverbs. The real facts are that an individual acts intelligently, consciously or unconsciously, skillfully, speedily. An adverb denotes not a separate activity but some characteristic of activity. It is a safe rule, on encountering any psychological noun, to strip off its mask and uncover the activity concealed beneath.

REFERENCES

Boring, E. G. *History of experimental psychology.* 1929.

Burt, C. L. *The young delinquent.* 1925.

Garrett, H. E. *Great experiments in psychology.* 1930.

Goodenough, F. L., & Anderson, J. E. *Experimental child study.* 1931.

Judge Baker foundation. *Case studies.* Nos. 1–20. 1922.

CHAPTER III

INDIVIDUAL DIFFERENCES

The individual, our object of study, is decidedly a variable quantity. The same individual varies from time to time, and one individual varies from another. How then, it may be asked, can we ever hope to reach any general laws in psychology?

In the early days each psychologist naturally assumed that he himself was a typical individual and that what he found to be true of himself could be accepted as a general law. If in thinking of an absent object he found himself picturing it "before his mind's eye," he proceeded to announce a general law of thought, to the effect that anyone thinks of an absent object by means of a visual memory image derived from previously seeing the object. Another psychologist on the contrary found himself thinking in words and not in visual images, and accordingly announced the law that thought consists in internal speech.

The fact that individuals differ greatly in memory images was established in 1883 by Francis Galton, who more than anyone else was the founder of the psychology of individual differences. Galton put the same questions to many individuals: "Think of your breakfast table as you sat down to it this morning. Does the scene come back vividly to you? Do you see the whole scene at once? Are the objects distinct? Are the colors bright and lifelike?" Some persons answered, "Entirely so," and others, "Absolutely not." Most people gave intermediate answers. Galton found that the answers could be arranged in order from one extreme testifying to highly realistic images to the other extreme denying any images at all. Those who denied images reported that they remembered the breakfast table without seeming to see it.

Type theories. Galton's imagery experiment has been repeated many times with the same result. Some individuals who denied having visual images reported that they could call up sounds or odors or the feel of various objects; and a theory grew up which divided mankind into several "imagery types," principally the visual, the auditory and the motor. Every individual, so the theory ran, belonged to one or another of these types. One person was said to be "eye-minded," another "ear-minded," still another "muscle-minded," and so on.

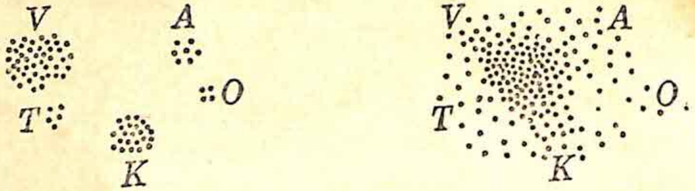


FIG. 4. — Individual differences in mental imagery. According to the type theory, at the left, every individual has a place in one or another of the distinct groups, visual, auditory, tactile, kinesthetic, or olfactory. According to the facts, the majority of individuals cluster in the middle space, and form a single large group, though some few are extremely visual, or auditory, etc., in their imagery.

Further investigation showed that a "mixed type" must be admitted to take care of individuals who reported images of two or more different senses; and the mixed type was later found to be the most common of all. Very few individuals, it is now known, are limited to images from any one sense. Nearly everyone runs predominantly to visual images but with occasional images of sound, smell, touch, and bodily movement. The typical individual, then, is one of mixed type, and the rare individuals taken to represent pure types are really *atypical.*

Other type theories have had a similar history. The exceptional individual, because he stands out from the mass, is taken as a type; an opposed type is found and the attempt is made to classify people under one or the other of the opposing types. Soon individuals are found who lie midway between the extreme types, and a "mixed type" has to be admitted. On further investigation the great majority of individuals are found to belong to the mixed type. The net result of many such experiences is the conviction of psychologists that individuals differ in degree rather than in kind. They *deviate* in one direction or another from the general average, the majority lying rather close to the average but a few deviating widely to this side or that. This law of *distribution about an average* is the fundamental law of individual differences.

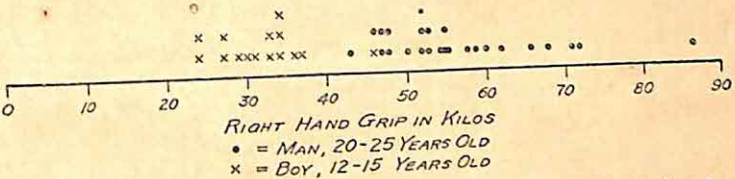


FIG. 5. — The distribution of men and that of boys in right hand grip. Each man is represented by a dot, each boy by a cross.

Psychological tests. To study an individual, we need to compare him with other individuals or with the average of his group. For such purposes we need suitable measuring instruments, analogous to the yardstick for measuring the height of the individual and to the scales for measuring his weight. A psychological test measures the individual's activity along one dimension, and makes it possible to compare different individuals in this respect. Among the early tests, designed by Galton and other pioneers, were some for measuring sight, hearing, motor skill, memory and other special abilities. The now familiar intelligence tests came later. Hundreds of tests have been devised, and a considerable number of them found to be worth while.

No matter what test is used, individuals differ one from another. As an illustration we take a familiar test, the hand dynamometer for measuring the "grip." The subject takes the dynamometer in his hand and gives it a quick squeeze with all the force he can muster. His grip depends not simply on the strength of his muscles, but also on skill in handling the instrument and on concentrated effort. The results obtained will serve to illustrate the distribution of individuals along a dimension. Twenty-five men, aged 20–25, and fifteen boys, aged 12–15, took this test, making scores which can be pictured in a diagram. Each individual is represented by a dot or cross and his score can be read from the scale along the base line. Where two or more individuals make the same score, their dots are piled above the appropriate point of the scale. The scores of these men range from 43 to 87 kilos, but most of them lie rather close together, with a few scattering towards either extreme. The boys are similarly aggregated about another point of the scale. The difference between the two groups shows up very clearly in the diagram, and illustrates one use of tests, that of comparing groups of individuals, age groups for example. Another use is that of comparing one individual

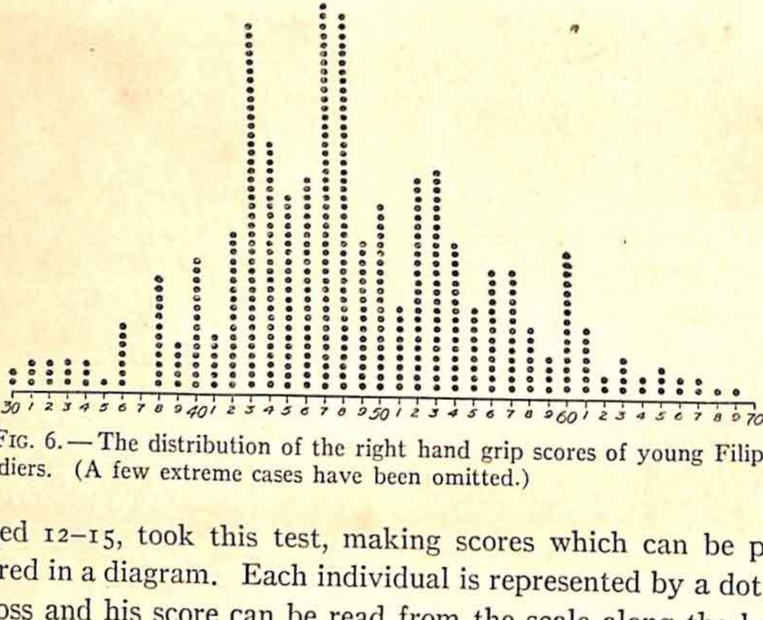


FIG. 6. — The distribution of the right hand grip scores of young Filipino soldiers. (A few extreme cases have been omitted.)

with another, or better with the group with which he properly belongs. If we were interested in any particular individual and could identify his dot in the diagram, we could see clearly where he stood in his group.

THE DISTRIBUTION CURVE

The law of distribution is better shown by a large collection of individuals, located by dots above a base line in the way

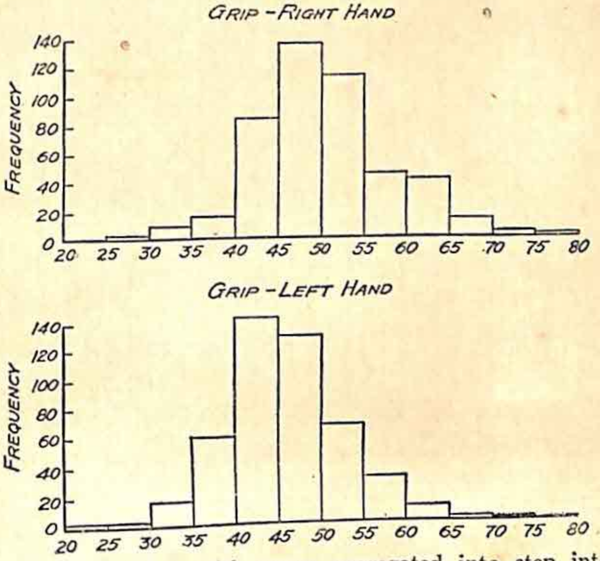


FIG. 7.—The same, but with scores aggregated into step intervals of 5 kilos. The left hand grip is also shown on the same scale so that the two distributions can be directly compared.

just shown. The piling up of many scores near the middle of the range and the tapering off towards each extreme give the whole diagram somewhat the outline of a bell. If we should sketch in the general outline, smoothing off chance irregularities, we should have a distribution curve. The usual curve has a single high point, called the "mode," where the frequency of individuals is greatest. The frequency goes down on each side of the mode, giving a curve with some approximation to symmetry. If we follow the curve from one end to the other, we see that its curvature is upward at the sides and downward at the middle.

The distribution diagram can be simplified by combining adjacent piles into "step intervals" of convenient width, and by substituting rectangles for the piles of dots. In this way the upper part of Figure 7 has been derived from Figure 6. The lower part shows the distribution of the left hand grip for the same individuals, and the two distributions can be directly compared by the eye to bring out the difference between the hands.

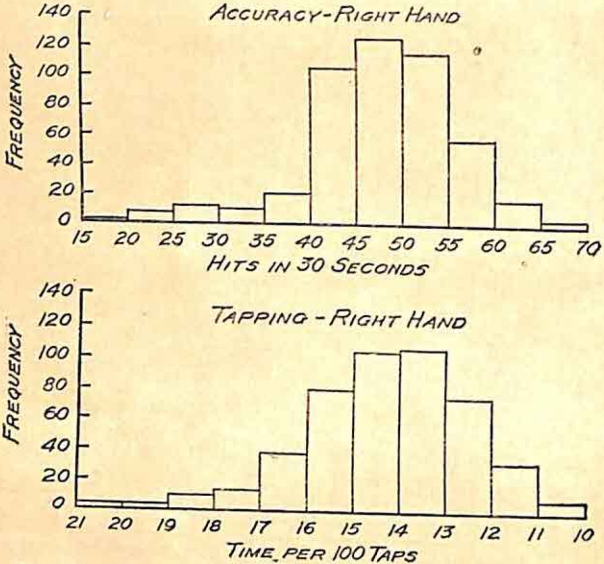


FIG. 8. — Distribution of the same subjects in the three-hole accuracy test for the right hand, and also in the tapping speed test for the right hand.

Other manual tests. If we wished to determine the manual ability of an individual or group, we should certainly test for accuracy and speed of movement as well as for strength. One test for accuracy of hand movement, called the "three hole test," presents as targets three small holes lying four inches apart in a triangular piece of board. The subject, armed with a metal stylus having a wooden handle, moves quickly around and around the triangle of targets, inserting the stylus into each hole in turn, closing an electric key at the bottom of the hole and thus ringing a bell. His task is to ring the bell as many times as possible within half a minute, time being taken with a stop watch. The task calls for speed as well as accuracy, but inaccurate speed will not avail, since the stylus must reach the bottom of a hole in order to register. The scores of a large group of subjects are distributed in an accompanying diagram.

The "tapping test" calls for quickness alone. Again the subject holds a stylus, but now he has only to execute an up-and-down vibratory motion, making and breaking contact between the end of the stylus and a brass plate screwed to the table. An electric counter records the interruptions of the circuit and so the number of taps. The subject is given a flying start and timed for 100 taps.

No bimodal curves such as are demanded by the type theory. The distribution curves obtained from different tests are not all precisely alike. Some show a bunching of individuals towards one end, while some are very nearly symmetrical and "normal." But none of them are genuinely bimodal. If individuals could properly be classified as either quick or slow, the tapping test would separate them into two bunches, instead of showing them bunched around a single mode. When only a small number of individuals is tested, the distribution often looks bimodal; but increasing the number of cases is sure to fill in the gaps. Of course, if one half of the individuals are already well practiced in the performance while the other half are new to it, an artificial modality is likely to appear.

The distribution curve from an adequate sample of any group or population gives a picture of that population in one particular respect, i.e., in respect to the dimension which is measured by the test employed. In any single dimension the population is strung out within a certain range of ability, but bunched about a point lying near the center of the range.

How to measure a distribution. Though the distribution curve presents the facts graphically, it does not suffice for exact work. We should like to state the facts numerically. We need some way of stating the *center* around which the individuals are distributed, and some way of stating the amount of *scatter*.

The mode is about at the center of the distribution, but cannot readily be measured. The average is the best general value for the center, and every one knows how to compute the average: add up all the scores and divide by their number. When the distribution is completely symmetrical, the average coincides with the mode.

As a measure of scatter, we could take the whole range, except that it depends entirely on the extreme cases and so is unstable and undependable. A good measure of scatter should tell how far the individuals in general deviate from the average. We may therefore find the distance of each individual score from the average, add up all these deviations and divide by the number of individuals, so obtaining the "average deviation." The best measure of scatter, however, is the *standard deviation*, or S.D., obtained by squaring each individual deviation, then adding them, dividing by the number of cases and finally extracting the square root.

The justification for this roundabout procedure, and the short and convenient methods that have been worked out for computing the average and the S.D., will have to be left for books on statistical method. Here we do not attempt to go into the mathematical theory nor to practice using the methods. We wish only to see the need of such methods in the study of individual and group differences.

One use of the statistical measures can be seen by turning again to the distribution diagrams for the right hand and left hand grip (Fig. 7). It is easy to see from the diagrams alone that the right hand grip runs larger than the left. But how much larger, and how reliable is the difference? Computation yields the following values:

	Right hand	Left hand
Average	49.8 kilo	45.3 kilo
S.D.	7.5 "	6.6 "

On the average, then, the right hand was 4.5 kilos stronger than the left. Shall we accept this superiority of the right hand as well established for the population of which we have tested only a sample? The sample was large and should therefore be representative. The obtained difference, however, is rather small, and the scatter, as shown by the S.D., is rather wide. The wider the scatter the less reliable is the average obtained from the sample. Statistics provides a method of taking account both of the scatter and of the size of the sample and from them estimating the reliability of the average. In the present case the statistical method shows that the obtained difference is highly reliable, so that the right hand is proved to have a stronger grip than the left in the population in question. Though this result is not startling, it serves as an illustration of the precautions needed when tests are used for obtaining scientific results.

How to locate the individual in the group. When an individual has been tested, how shall his score be expressed so as to say something meaningful about him? An isolated measure means nothing at all. If we had before us the isolated fact that a certain individual had a right hand grip of 60 kilos, we should not know whether to call him weak or strong. We compare him with the average, and find him to stand 10.2 kilos above the average. We compare his individual deviation with the standard deviation of the group, and find him to stand

$10.2/7.5 = 1.36$ S.D. units above the average. Thus we know exactly where he stands in the distribution. In general we characterize the individual by locating him in the group distribution.

CORRELATION

We can now take a further and very important step in our study of individual differences. Suppose the same individuals to have taken two tests. Then we can ask how closely their standings in one test *correspond* with their standings in the other. Does the same individual who scored highest in one score highest in the other also, and is the second individual in the one the second in the other, and so on down the line? If so, there is a practically perfect "correlation" between the results of the two tests.

The correlation diagram. We need to locate each individual along two scales. If he stands high in the first test we place him towards the right side of our diagram, and if he stands high in the second test we place him near the top of the diagram. A single dot indicates his two scores. For example the same men and boys whose right hand grip is shown in Figure 5 tried the left hand also, and their scores in both tests are shown by the dots and crosses along the diagonal of Figure 9. (The dots and crosses along the base line simply show again the distribution for the right hand.) The dot in the upper right hand corner reads that one man scored 87 kilos with the right hand and 84 with the left; and similarly each dot can be read. All the scores cluster about a line which rises obliquely to the right. Clearly there is a strong positive correlation between the grip of one hand and that of the other. If all the dots and crosses lay exactly on the oblique line the correlation would be perfect, and you could predict the left hand grip precisely from the right. This diagram, with men and boys both included, may be said to show almost perfect correlation between the strength of the two hands.

Correlation of different manual abilities. Let us see, however, how the correlation diagram of right and left hand grip will look when the sample is large and confined to young

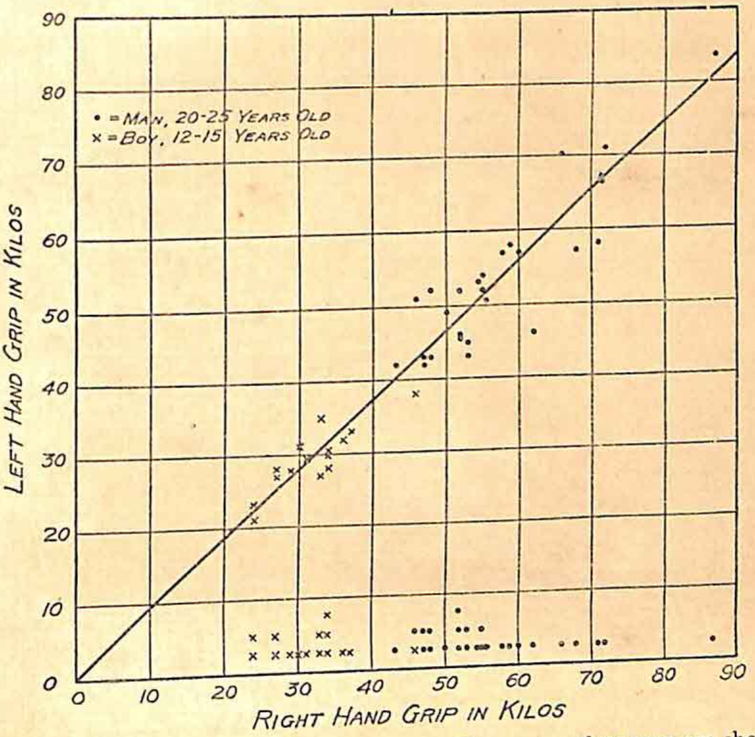


FIG. 9.— A correlation diagram or chart. The scores of 25 men are shown by dots, and those of 15 boys by crosses. The dots along the base line simply repeat the right hand distribution given in Fig. 5. Each of these dots may be thought of as moved up till it reaches the level of the same individual's left hand score. When the men and boys are lumped together, the correlation between the right and left hand grip measures +0.97.

adult men. (Fig. 10). The general slant is clearly upward and to the right, indicating a positive correlation, a definite tendency for those who grip strongly with one hand to do so with the other. But the correlation is moderate rather than close or "high." Very similar diagrams appear on plotting together the right and left hand scores in accuracy or in tapping. We can infer that the causes that make for manual efficiency are largely but not entirely common to the two hands.

But now let us ask whether strength, speed and accuracy go together. We take two of them at a time, as in Figure 11, and obtain a diagram with a wide scatter and little sign of any oblique slant. The three dimensions of manual ability can have very little in common. There is only a very slight tendency, among adult males, for an individual who has a strong grip to be especially quick in the tapping movement or accurate in the three-hole test.

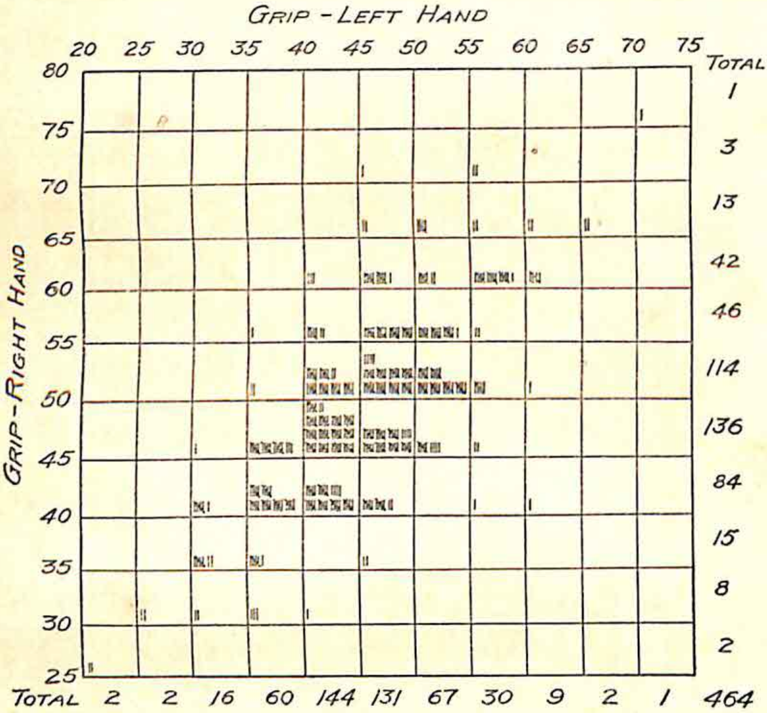


FIG. 10. — Correlation chart for right and left hand grip with 464 Filipino soldiers as subjects. The right hand grip is here measured along the vertical axis and the left hand grip along the horizontal axis. The numbers below and along the right give numbers of cases in the columns and rows. The correlation coefficient here = +0.74.

The correlation coefficient. It is clear that some measure of correlation is needed. The correlation charts yield in most instances only a rough impression of the closeness of correlation. Let us adopt the convention of calling a correlation 100 percent or 1.00 when it is perfect, and 0 when there is no correspondence at all between the two sets of scores. If high scores in one test tend to go with low scores in the other, we shall call the correlation negative, and a perfect negative correlation is to be represented by −1.00. Our correlation measure must thus be capable of taking any value from +1 down through 0 to −1.

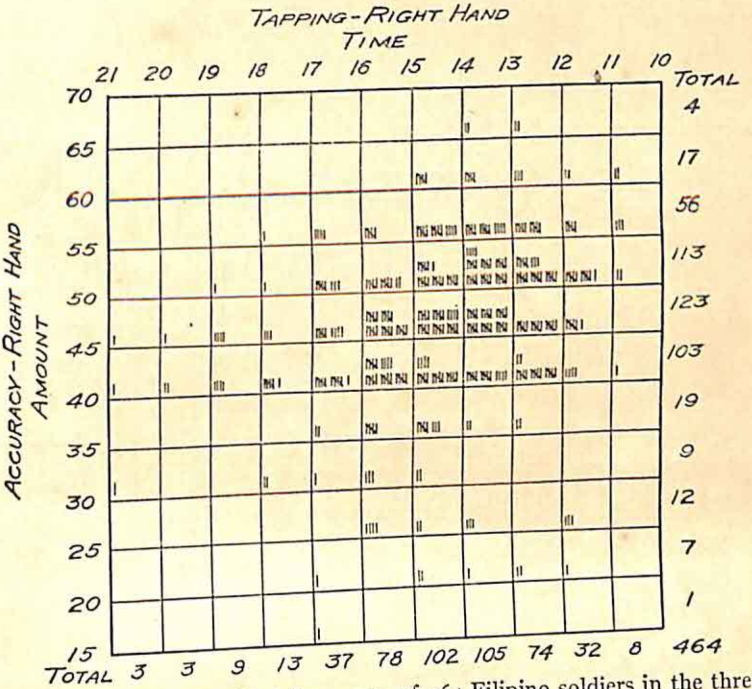


FIG. 11. — Correlation chart for scores of 464 Filipino soldiers in the three-hole accuracy test (vertical dimension) and the tapping speed test (horizontal dimension), both for the right hand. The numbers below and at the right give numbers of cases in the columns and rows. The correlation coefficient here = +0.25.

In accordance with this convention, Karl Pearson, one of Galton's chief English successors, devised a formula which is known as the Pearson coefficient of correlation, and designated by the letter *r*. Let two tests be labelled X and Y. Find the average of the X scores and that of the Y scores. Find each individual's two deviations, one from the X average, the other from the Y average, calling his deviation + when his score is better than the average and — when poorer. Multiply each individual's two deviations together, keeping account of signs, and add all these deviation-products together, still keeping account of signs. Divide this product by the product of the three numbers: the number of cases, the S.D. of the X distribution, and the S.D. of the Y distribution. Thus we have

$$\mathrm{r} = \frac{\text{Sum of deviation-products}}{\mathrm{N} \times (\text{S.D. of X}) \times (\text{S.D. of Y})},$$

or, in more compact symbols,

$$\mathrm{r} = \frac{\text{Sum xy}}{\mathrm{N}\, \sigma_x\, \sigma_y},$$

where x and y are each individual's deviations from the X and the Y averages, and σ_x and σ_y are the S.D.s of X and Y.

Correlations of various abilities. Even though one has no occasion to compute correlations, one often finds correlations stated and needs to have some realistic sense of the closeness of correspondence indicated by a coefficient of .50 or .80, etc. Some idea of the concrete meaning of different values of *r* can be had by noticing the value given for each of the correlation diagrams already shown. The following table will help. We see that Stature and Arm Spread are correlated to the extent of +0.82; we should expect a close correlation, since a person can usually spread just about his height or a little more; but the coefficient shows that the correspondence is by no means perfect. Stature and Weight are less closely correlated (r = 0.59) as we should expect since various factors affect weight that are independent of height. Correlations higher than 0.85 are seldom obtained except for two tests of the same ability.

A FEW CORRELATION COEFFICIENTS

(from various sources)

Anthropometric and strength tests	
Stature and Arm Spread, men	.82
Stature and Weight, men	.59
Stature and Grip, men	.43
100-yard dash and Grip, women	.16
Scholastic tests	
Word Meaning and Paragraph Meaning	.80
Arithmetic: Computation & Reasoning	.70
Punctuation & Spelling	.60
Vocabulary and Spelling	.50
Reading and General Information	.40
High School Grades	
Algebra and Geometry	.65
English and French	.50
English and Art	.15
College grades (West Point)	
Two English courses	.77
English and History	.68
English and Physics	.50
English and Mathematics	.42
English and Drawing	.27
Mathematics and Physics	.74
Mathematics and English	.50
Mathematics and History	.45
Mathematics and Drawing	.44

Uses of the correlation cœfficient. It will be enough to speak of a few psychological uses. In the construction of tests, great care is necessary to make them as good measuring instruments as possible. There are two qualifications of a good measuring instrument that are specially desired, called by psychologists validity and reliability.

Validity is present when the test measures what it is designed to measure. This point comes out most clearly in tests for vocational guidance or selection. The psychologist prepares a test (or battery of tests) for predicting how well an individual will succeed in a certain occupation. If the test is valid, his predictions based on the test will check with the individual's success or failure in the occupation. Actual success or failure is here the "criterion" against which the test must check; and the test must correlate highly with the criterion in order to possess high validity.

Reliability is present when the test establishes the individual's position definitely in the particular ability tested. If a test is repeated, or if equivalent tests are given to the same individual, and he comes out with the same standing each time, the tests used are reliable. A thoroughly reliable test must have a self-correlation of .90 or above, though many acceptable tests do not fully meet this standard.

Correlation as a method of psychology. Alongside of the experimental and genetic methods we should place the correlation method. It is a means of examining the relations between abilities or performances. The correlation of +0.74 between right and left hand grip means that there are important strength factors common to the two hands; whereas the correlation of only +0.25 between strength and speed of hand means that there is only a little common to these two abilities. A correlation of +1.00 between two tests — which is never obtained — would mean that two completely identical abilities had been discovered. By systematic exploration this method of attack can reveal the general organization of abilities.

Like the experimental method, correlation takes two variables at a time and notes changes in the one that go with changes in the other. In correlation the two variables are on a par, and neither more than the other is the independent variable. Neither is controlled in the experimentalist's sense.

In examining the relation of arithmetical reasoning to facility in computation, the correlation method assembles a representative sample of school children and tests them in both lines; obtaining $r = +0.70$, we conclude *not* that good computation is a cause of success in reasoning — for the good reasoning might conceivably be the cause of the success in computation — but that the two performances have important factors in common.

Significance of individual differences. The social group is composed of individuals who are different. Besides age and sex differences, there are large differences among those of any age and sex group. Certainly the world would be altogether a different world for man if all men were alike. The child must learn to adjust himself, not to one standard adult but to adults who behave differently towards him. Thus the distribution curve, as was said before, is a revealing picture of the social group.

Equally important as an element in the picture is the moderate positive correlation that usually appears between any two desirable traits. If the correlation were extremely high, so that those who excel in one line were sure to excel in every line — or if the correlation were negative, so that disabilities in one line were sure to be compensated for by abilities in some other line — again the world would be very different from the one we know. On the whole there is more correspondence than compensation.

As to the causes of individual differences, one thinks of heredity and environment, with training included under the latter head. Before sifting this question we will examine some of the most important variations between individuals, under the heads of intelligence and personality.

REFERENCES

Galton, F. *Inquiries into human faculty and its development.* 1883.

Garrett, H. E. *Statistics in psychology and education.* 1926.

Garrett, H. E., & Schneck, M. R. *Psychological tests, methods, and results.* 1933.

Holzinger, K. J. *Statistical methods for students in education.* 1928.

Hull, C. L. *Aptitude testing.* 1928.

Whipple, G. M. *Manual of mental and physical tests.* Pt. 1, 1914. Pt. 2, 1915.

CHAPTER IV

INTELLIGENCE

Intelligence is one of the dimensions in which individuals differ. We speak of one person as more intelligent than another, and coming closer to the facts we say that one act is more intelligent than another. One person is more intelligent than another if he acts intelligently to a greater degree or for a larger fraction of the time. "Intelligence" is one of those nouns that are properly adverbs, and the noun is only a shorthand symbol for the fact of behaving intelligently. We wish to find out in what intelligent behavior consists, on what factors it depends, and what difference it makes in a person's life.

However logical it may appear to insist first of all on a definition, psychologists actually began by measuring intelligence and finding its relationships, and only gradually are they approaching a definition. At the outset a rough preliminary definition was sufficient to indicate the field they were proposing to explore.

Intelligence as a word is closely related to *intellect*, a term formerly much used in psychology. The intellect was regarded as one of the three main "faculties of the mind," the other two being feeling and will. "Intellect" is merely a shorthand expression for observing, thinking, remembering and all kinds of *knowing*. Intellectual activity yields knowledge of the facts of a situation. Intelligent activity does this and something more. It is *useful*; it helps the individual in reaching a goal. Counting, for example, is an intellectual activity and yields knowledge, but counting the pods would not be an intelligent way to start shelling a mess of peas. Intelligent behavior, then, is behavior conforming both to the situation and to the goal. This preliminary definition is enough to delimit the field which psychologists are studying under the head of intelligence.

THE MEASUREMENT OF INTELLIGENCE

Psychological work on intelligence started from the practical side. About the year 1900 the school authorities of the city of Paris, disturbed by the large number of children who were backward in their school work, decided to find out whether this backwardness was due to inattention and mischievousness, as the teachers were apt to assume, or to insufficient ability. Alfred Binet, one of the leading psychologists of the day, set about to find the answer. After experimenting with various possible methods of measuring the intellectual ability of children, he came to the conclusion that no single performance would serve as a fair test. It was necessary to give the child plenty of chances to show his ability in different lines. Accordingly the Binet-Simon scale, prepared by Binet and his collaborator, was an assembly of many little tests, each of which was passed or failed, so that the total number of successes gave the subject's score. The separate tests needed to be graded in difficulty from very easy to very hard, so as to measure all degrees of ability; and just here Binet had the brilliant idea of utilizing the known fact that children increase in intelligence as they grow up. His easiest tests were just within the reach of three-year-olds, the next easiest beyond the average three-year-olds and just within the reach of four-year-olds; and so on up the scale. As he could not tell by inspection the exact difficulty of the various test items, he tried them on children of different ages, and introduced such modifications as were found necessary to fit each item for a certain age level. Years of experimentation, and several revisions, were necessary before the Binet scale became a fairly accurate instrument for measuring the intelligence of children, and Binet himself died in 1911, before his task was fully completed.

Binet's tests were soon adapted for use in various countries. Terman, in the United States, improved the tests in detail, and carried the scale up to the adult level, while Kuhlmann extended the scale downward to the age level of a year and less. A few samples from the Kuhlmann and Terman revisions will give some idea of the character of the Binet tests. There are usually six varied tests at each age level.

3-month level: carrying the hand to the mouth by a definite rather than merely a random movement.

6-month level: reaching for a small bright object dangled before the child within his reach.

12-month level: imitating an action such as shaking a rattle or ringing a small bell.

2-year level: removing the paper wrapping from a piece of candy before putting the candy into the mouth.

3-year level: naming familiar objects — the child to pass the test must name at least three out of five familiar objects that are shown to him.

6-year level: finding omissions in pictures of faces, from which the nose, or one eye, etc., is left out. Four such pictures are shown, and three correct responses are required to pass the test.

8-year level: telling how wood and coal are alike, and the same with three other pairs of familiar things; two correct responses required to pass the test.

12-year level: vocabulary test — rough definitions showing understanding of 40 words out of a standard list of 100.

14-year level: telling the three main differences between a president and a king.

The question may be raised, "Why such arbitrary standards — three out of four required here, two out of four there, forty out of a hundred in another test?" The answer is that the standards are not really arbitrary, but agree with what the average child of a given age actually does with the tests.

Special training, in addition to the right way with children, is necessary for the psychological examiner who wishes to use these tests. Unless the examiner can enlist the child's interest and effort, while still giving the tests in the standardized manner and scoring each answer in the standardized way, the tests will give false results. The Binet scale is one of the psychologist's instruments of precision, and the novice must learn the technique of it from the expert.

Scoring of the Binet tests. With each separate test scored as passed or failed, the individual's total "raw score" is simply the number of tests passed. Older children make larger scores, on the average, than younger children, and the average score increases regularly from year to year during childhood and early youth. For each age, then, there is a *norm* or average score, and any raw score is the norm for some age. So, any raw score can be translated into an age equivalent, which is called the *mental age*. A person who makes a certain score is said to have the equivalent mental age. Any person, no matter what his chronological age, whose score in the tests is equal to the norm for 8½ years, is said to have a mental age of 8½ years. More precisely, he is said to have a "Binet test age" of 8½ years. Other tests, different in content from the Binet, can be scored in terms of mental age or test age, provided they have yielded a progressive series of age norms. In general, then, mental age is a measure of mental development, obtained by seeing what age norm the individual reaches in the given type of performance. This graphic way of stating the results of the Binet tests has much to do with their widespread use.

The Intelligence Quotient. Evidently a child's mental age, alone, does not tell how bright he is. A child with a mental age of 8 years is a dull child if his chronological age is 12 years, but a bright child if his chronological age is 5 years. The mental age and the chronological age need to be considered together. A convenient way of putting them together is to divide the mental age by the chronological age, and thus obtain the Intelligence Quotient, or IQ. A child with a mental age of 8 years and a chronological age of 12 years has an IQ of 8/12 or .67, while another child with the same mental age but a chronological age of only 5 years has the much higher IQ of 8/5 or 1.60. The exactly average child has a mental age equal to his chronological age, and his IQ is therefore 1.00.

It is customary to omit the decimal point. The exactly average child, of any age, is said to have an IQ of 100; an IQ of 70 lies far below, one of 130 far above the average.

Performance tests are intelligence tests which, as compared with the Binet, make little use of oral question and answer, and more use of concrete materials. They are specially needed for testing anyone with a language handicap, due often to insufficient acquaintance with the language spoken in the testing. Some persons, even without any language handicap, do better when dealing with concrete objects than when answering questions about objects which are only spoken of and not actually present. The "form board" is a good example of a performance test. Blocks of different shapes are to be fitted into corresponding holes in a board; the time of performance is measured, and count is kept also of the errors, consisting in trying to put a block into a differently shaped hole. To the average adult, this task is too simple to serve as a test of intelligence, but the young child finds it difficult, and the adult of low mental age goes at it in the same haphazard way as the young child, trying to force the square block into the round hole. He does not pin himself down to the one essential requirement of matching blocks and holes according to their shape.

A picture drawing test has been found good for the younger ages, from four to ten. The child is simply asked to "make a

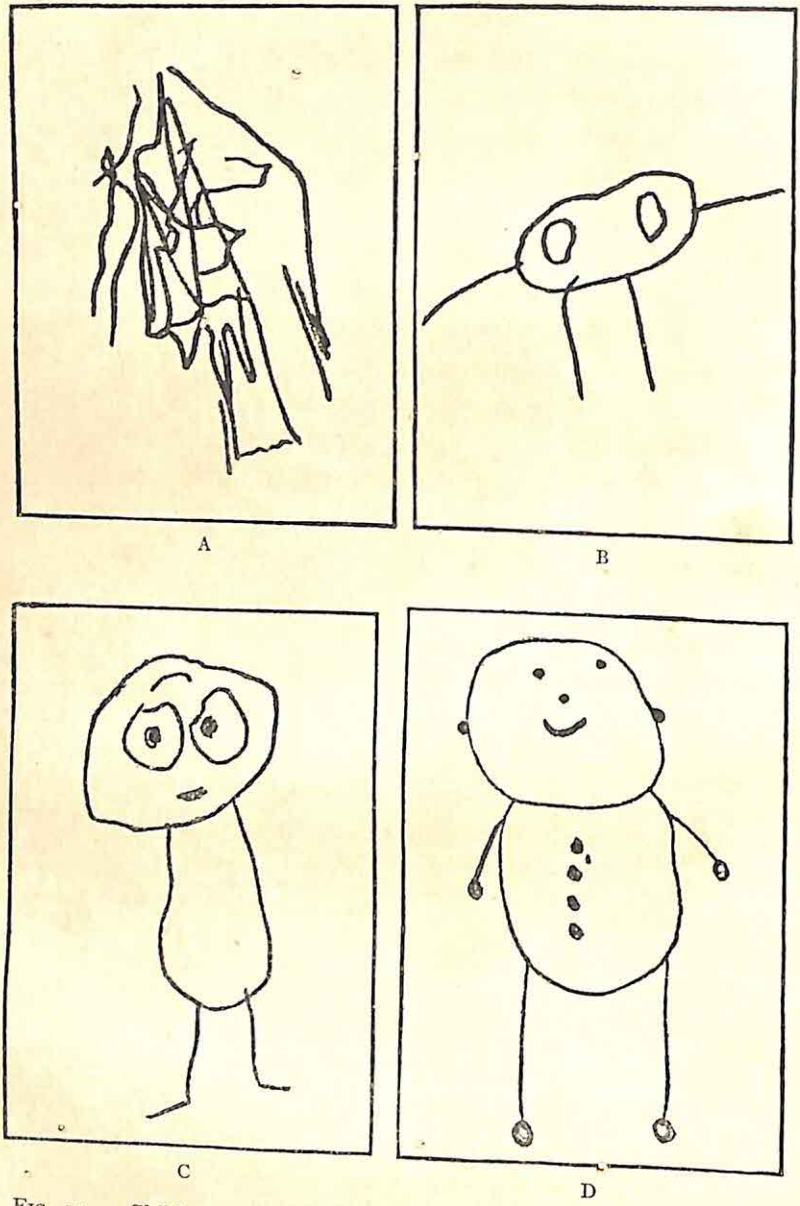
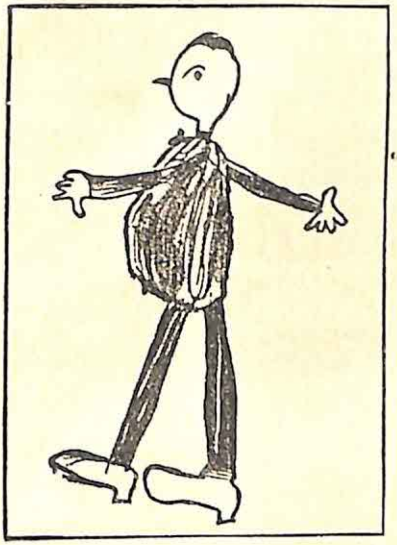


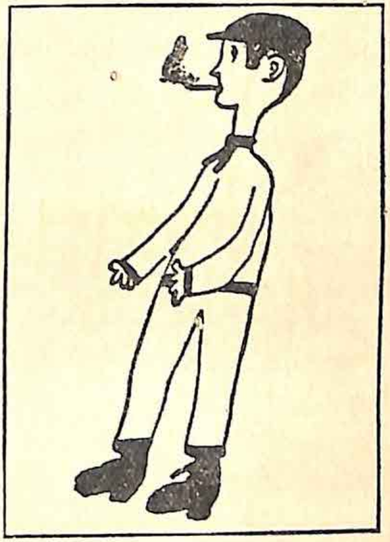
FIG. 12. — Children's drawings of a man, from F. L. Goodenough. (3)[1]

---

[1] Numbers in parentheses refer to the "References" at the end of each chapter.



E



F

A. Score 0, M.A. (mental age), less than 3 years.

B. Score 4 points, for head, legs, arms, eyes; M.A., 4 years.

C. Score 8 points, for head, legs, trunk, trunk longer than wide, eyes, pupils of eyes, mouth, forehead; M.A., 5 years.

D. Score 14 points, for head, legs, arms, trunk, trunk longer than wide, arms and legs attached to trunk, eyes, nose, mouth, ears, hands, legs in fair proportion to trunk, some clothing, firm and well-controlled lines; M.A., 6 years, 6 months.

E. Score 26 points, including most of those mentioned above, and in addition: shoulders, neck, neck continuous with head, hair, clothing non-transparent, fingers, thumbs, arms and legs shown in two dimensions, heels, head in fair proportion, eyebrow; M.A., 9 years, 6 months.

F. Score 44 points, including most of those mentioned above, and in addition: lips, nostrils, elbow, knee, projecting chin, profile, eye detail (4 points), ears in correct position and proportion, arms attached at right point, hair non-transparent and well shown, good proportion of head, arms, legs and feet, good lines and motor control (3 points), costume complete without incongruities (5 points): M.A., 13 years or over.

man, the best man he can make," with pencil on paper. The child's drawing is scored not for esthetic value but for completeness and coherence. Age norms were obtained by closely scrutinizing the actual performance of many children at each age. The advance with age consists partly in the inclusion of more items in the picture, partly in putting the items in better relation to each other (as in attaching the arms to the trunk rather than to the head, as younger children often do), and partly in representing the man as he could be seen at one time (not combining two eyes with a profile, nor showing the legs through the trousers). A child whose performance is on a level with that of the average five-year-old has a mental age (man drawing age) of five years.

Yet another style of performance test is provided by a maze on paper, through which the shortest path has to be followed with a pencil. In order to prevent the pencil from straying into a promising blind alley, the maze has to be followed through by the eyes and not attacked blindly and impulsively.

Group tests are given to a number of individuals at once, as in ordinary school examinations. Economy of time is the primary consideration in their use, but it is also true that some persons do better in a group than when under the direct eye of the examiner, so that a combination of individual and group tests is desirable.

The first extensive use of group tests was made in the American Army during the World War for the purpose of detecting both the dull recruit who was scarcely capable of learning the duties of a soldier, and the bright one who could quickly learn the duties of an officer. The Army Alpha was a test for those who could read English, and the Army Beta for illiterates and foreigners. Alpha contained a page of arithmetical problems, ranging from extremely simple ones at the top of the page to more complex ones at the bottom; a page calling for distinguishing synonyms and opposites; and a page calling for items of information. These three sub-tests depend strongly upon *knowledge* previously acquired by the subject. Among the remaining sub-tests were three that called mostly for *alertness*

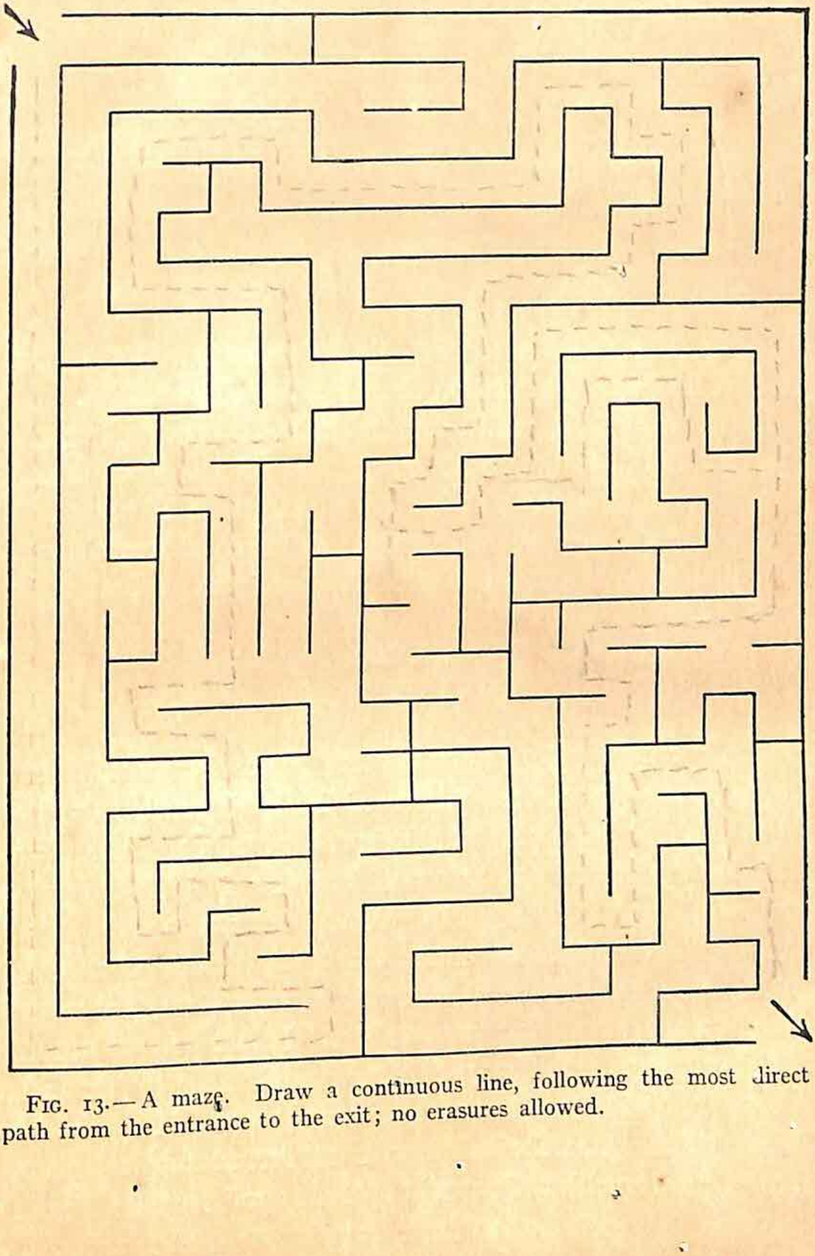


FIG. 13.—A maze. Draw a continuous line, following the most direct path from the entrance to the exit; no erasures allowed.

and mental flexibility: following oral directions; completing number series, such as:

1 3 2 6 3 ... ...
49 36 25 16 9 ... ...

each line giving a different type of series; and "analogies" or "mixed relations" such as:

left — right : : up — front, rear, down, town
knife — blade : : arrow — spear, head, bow, shoot

the subject being asked to select the best word for fourth place in each line, and the relation changing from line to line.

In the Army Beta, which was conducted by pantomime and blackboard illustration, with practically no use of even oral speech, there were among other tests pictures to be completed by drawing in a missing part; mazes; and rows of symbols with repetition of a pattern which was to be continued, as in the two lines below:

OXOXO
XOXOOXXOXO

Achievement tests. Several other types of tests have been devised after the general pattern of the intelligence tests, but with different purposes and different materials. There are tests for mechanical aptitude and for musical aptitude, which are useful in forecasting an individual's success in these directions. There are "achievement tests" in various school subjects. An achievement test differs from an ordinary school examination because it is "standardized" before being placed in use, by trying it on many children and finding the norm or average score for each age and for each grade. With this preliminary work done, the individual's test score can be translated into terms of "arithmetic age," "spelling age" or general "educational age," according to the test used. It may be found that a certain child's educational age (E.A.) is not keeping pace with his mental age; some improvement needs to be made in his education or in his attitude. In case of a bright child it is often found that both his M.A. and his E.A. are in advance of the grade where he is placed, so that he is capable of more rapid promotion. In such ways the combination of intelligence and achievement tests is of much value in fitting education to the individual child.

The materials used in an achievement test are drawn directly from the subject matter taught in the schools, and differ in that respect from the materials used in an intelligence test. The achievement test is not a fair intelligence test, for several reasons. First, it is too narrow in scope. Second, some children are less interested in their school subjects than others, and their achievement may not measure up to their ability. Third, the ordinary schoolroom does not afford an opportunity for each child to advance at his own rate. The average child can readily master the quantity of subject matter assigned in the course of a year. The slow child is given special stimulation to keep him up to grade. But the bright child who could master much more than the standard amount does not get a chance to do so, and consequently his school progress during a year does not keep pace with his mental growth.

These facts have an important bearing on the requirements for a real intelligence test. It is supposed (a) to be broad in scope, (b) to use materials that appeal to the child's spontaneous interest, and (c) to be drawn from fields of activity and experience in which each child is free to set his own pace. The standard tests meet these requirements rather well, though they are not yet perfect.

RESULTS OBTAINED BY USE OF THE INTELLIGENCE TESTS

Though the tests were designed and are generally used for practical use in guiding and assisting the individual child or adult, they are also useful in scientific investigations and have yielded some significant results.

The distribution of intelligence in the population. Individual differences are as pronounced here as in any dimension of human activity. About 60 percent of children have an IQ between 90 and 110, differing little from the exact average, while 20 percent are below 90, and 20 percent above 110. More in detail, the distribution is given in the following table:

IQ below 70	1% of all children
IQ 70–79	5%
IQ 80–89	14%
IQ 90–99	30%
IQ 100–109	30%
IQ 110–119	14%
IQ 120–129	5%
IQ above 129	1%

This distribution can be pictured in the form of a distribution curve. See Figure 14.

We see, then, a continuous gradation of intelligence from the high to the low extreme, with no gaps anywhere along the line and no distinct classes of bright, average and dull. It is the same unimodal distribution as is found in motor tests and in physical measurements like height and weight.

Constancy of the Intelligence Quotient. Since the mental age of the exactly average child is by definition equal to his chronological age, and since the IQ is the ratio of these two, it follows that the average IQ is the same for all ages, namely 100 But it is quite a different question whether the individual child maintains a constant IQ as he grows older. In general, the individual child's IQ remains almost the same from year to year, so that a fairly accurate prediction can be made, from the outcome of a test at the age of five or six.

as to what the subject's mental age is going to be when he is ten or twelve years old, or even older.

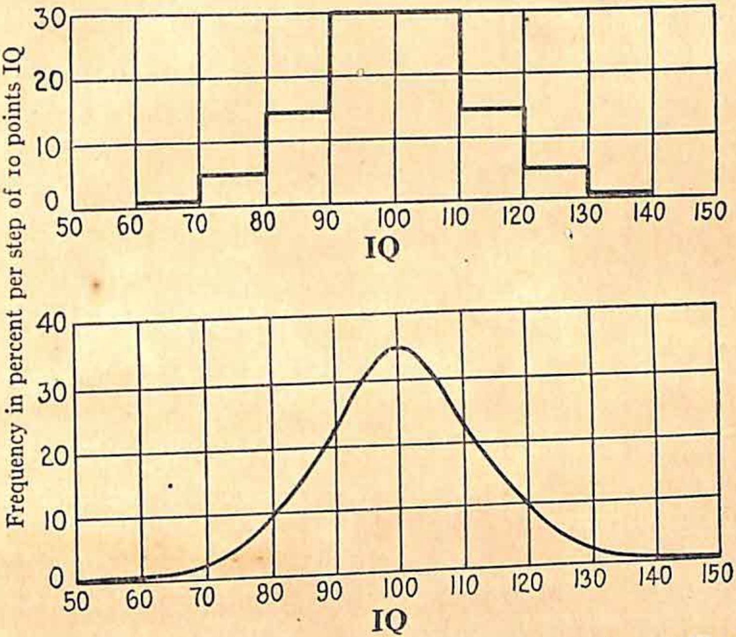


FIG. 14.—The frequency in the population of different values of IQ, represented in graphic form. The upper graph shows the frequency in each step of ten points, while the lower graph shows the same distribution in steps so small as to give a continuous curve. The smooth curve is the well-known "distribution curve." It does not really end at 50 or at 150.

Here, for example, is the record of a little girl, tested five times over a period of six years:

	Chronological Age		*Mental Age*		*IQ*
First test	6 years	8 mos.	5 years	6 mos.	83
Second test	7	1	5	4	75
Third test	8	2	6	10	84
Fourth test	8	7	7	0	81
Fifth test	12	10	9	10	77

She varies from 80 by only a few points up or down. Here is the record of another little girl, of about average intelligence:

	Chronological Age		*Mental Age*		*IQ*
First test	6 years	6 mos.	6 years	10 mos.	105
Second test	7	2	6	10	95
Third test	8	3	8	10	107
Fourth test	9	6	9	7	101
Fifth test	12	8	13	1	103

And here is a third girl, of high intelligence:

	Chronological Age		*Mental Age*		*IQ*
First test	4 years	9 mos.	6 years	8 mos.	140
Second test	7	4	10	4	141
Third test	10	9	15	1	140

It must be admitted however, that this last child is unusually constant; so we had better add another case with very high intelligence:

	Chronological Age		*Mental Age*		*IQ*
First test	5 years	3 mos.	9 years	3 mos.	176
Second test	6	2	9	5	153
Third test	11	5	16	4	143

This last girl does show a considerable drop from her original extremely high level, and yet she still remains well within the upper one percent of all children. Moreover, her mental age at the last test was up in the region where the tests are still far from complete and accurate (22).

But these are individual cases, which might easily be picked to give the impression either of constancy or of inconstancy. Retests of many hundreds of children, brought together from several sources, show on the average a change from the first IQ of about 5 points up or down, while a change of as much as 10 points appears in only 10–15 percent of all the cases. Moreover the changes which do appear in an individual are usually haphazard rather than progressively upward or downward.

A definite and permanent rise in IQ is found, however, after relief from such a handicap as partial deafness or blindness. The stimulus of a first-class school seems to have an appreciable though slight effect. In two very stimulating schools, which receive scarcely any children with an IQ of under 100, the gain in IQ from the time of entrance at the age of 5–8 years to the retest about four years later amounted on the average to 6 points. The accompanying diagram shows what happened in the cases of twenty-five of these children, each of whom had an IQ of 115 on entrance. Some moved down, more moved up, and the changes are somewhat greater than those usually reported, yet they are all small in comparison with the whole range of common IQ values.

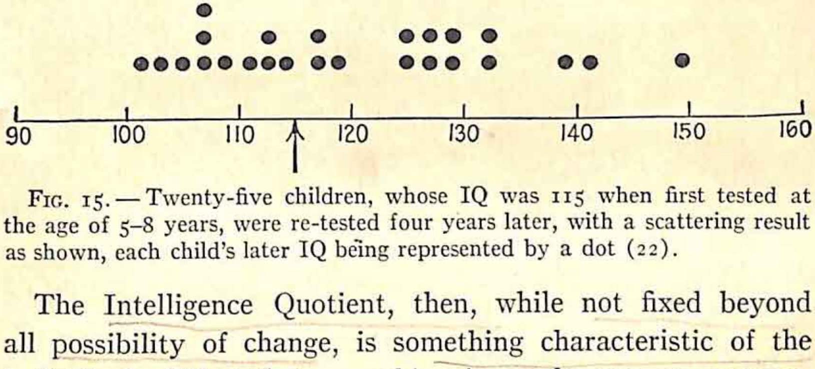


FIG. 15. — Twenty-five children, whose IQ was 115 when first tested at the age of 5–8 years, were re-tested four years later, with a scattering result as shown, each child's later IQ being represented by a dot (22).

The Intelligence Quotient, then, while not fixed beyond all possibility of change, is something characteristic of the individual. What that something is can be seen on comparing the IQ and the Mental Age. Mental Age tells the extent of the individual's mental development up to a certain time, Chronological Age tells how long it has taken him to reach that extent of development, and the quotient of the two, the IQ, therefore tells the *rate of mental development*, the speed with which it has progressed.

If two children test alike, with a Mental Age of 9 years, their development along the lines covered by the tests is equal.

But if one of these children is twelve years old, and the other six, the younger child has reached the nine-year level in half the time of the older child, and has thus advanced twice as fast. The bright child, with few exceptions, becomes the intelligent adult.

HOW LONG INTELLIGENCE CONTINUES TO DEVELOP

During childhood the score in the intelligence tests increases year by year. But how long does this development continue? Is intelligence like muscular strength which increases on into the twenties, or like hearing which is fully developed by the age of twelve and shows some falling off even before the age of twenty?

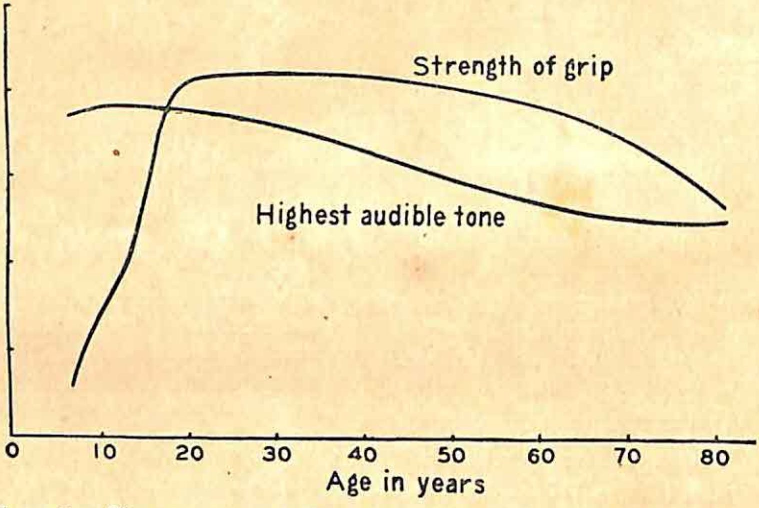


FIG. 16. — Two age curves. The measurements were made by Galton in 1884, and worked up by Ruger and Stoessiger (14). The total number of individuals (males) tested was about 7,000, and there was a considerable number in every age group between the ages 10 and 70. The curve obtained by this method of taking samples at each age is not exactly the same as would be obtained by testing the same individual at intervals from birth to death. The true decline in the later decades is undoubtedly steeper than here shown, because those individuals who age early are not here represented in the later decades, as they would have died or become too decrepit to visit the laboratory. The same reservation needs to be made in respect to the other age curves shown.

There are two ways to answer this question. ①Mental development can be followed up through the teens by repeated testing of the same individuals. Some studies of this sort have failed to find any advance beyond fourteen years, while others have shown a continued though slow improvement up to eighteen or even twenty.

② The other method of obtaining an age curve of intelligence through adolescence is an extension of the method used during the early school years: test a sample of the population at each age and compare the average scores of the age groups. So long as practically all the children remain in school, the age groups will be comparable samples. But as soon as any considerable number of children begin to drop out of school, the age groups remaining in school are no longer fair samples of the population.

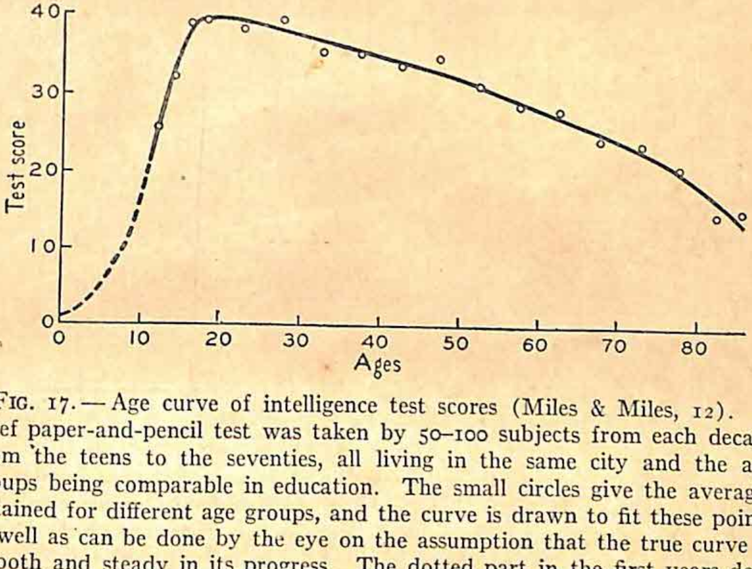


FIG. 17. — Age curve of intelligence test scores (Miles & Miles, 12). A brief paper-and-pencil test was taken by 50–100 subjects from each decade from the teens to the seventies, all living in the same city and the age groups being comparable in education. The small circles give the averages obtained for different age groups, and the curve is drawn to fit these points as well as can be done by the eye on the assumption that the true curve is smooth and steady in its progress. The dotted part in the first years does not rest on this series of measurements, but is sketched in to show the probable shape of the early growth curve.

The difficult task of obtaining comparable age groups viduals in any age group differ among themselves more than the average person of twenty differs from the average person of seventy. A considerable number of the seventy-year-olds surpass the average twenty-year-old.

We must admit that intelligence tests for adults are still imperfect and may not measure all the qualities that should be covered. But if intelligence and learning power reach their maximum at twenty this does not mean that the individual then ceases to learn and improve, but, on the contrary, that he has just reached his full powers of learning and improving. It is an advantage to him to have reached his full development, and to be fully equipped, so far as sheer intellectual power is concerned, for coping with the environment, for acquiring skill, knowledge and social poise, and for following out his chosen lines of activity.

INTELLIGENCE AND SUCCESS

Now that psychologists have succeeded in measuring something called intelligence, it is important to discover how this intelligence is related to success in life, as well as to the heredity and environment of the individual. This is important not only for vocational guidance and other practical purposes, but also for the scientific purpose of understanding the nature of the intelligence that has been measured.

Intelligence and scholastic success. The little children of six years and thereabouts, who assemble each year to begin their schooling, are of all degrees of intelligence except the lowest. They present almost a true picture of the general population as regards the distribution of IQ. Some of these children find school work easy and make rapid progress, "skipping a grade" once or twice in the next few years. Others make slow progress and have to repeat grades, and the bulk of the children are strung out between these extremes of school progress.

There is rather a definite correlation between the child's IQ and his ability to succeed in school. The correspondence between intelligence and school achievement is especially close when each child is given an opportunity to advance at his own rate.

An interesting experiment on this matter was tried in the public schools of New York City. Two classes were formed of children eight years old, twenty children in each class; all were of high intelligence, but one class consisted of children with IQ from 152 to 183, averaging 165, and the other class ran 20 points lower, averaging 146. The home environments were excellent and averaged the same for both the groups. The question was whether the difference of 20 points in IQ would make any difference in school progress. The experiment continued for three years, each child being allowed to proceed at his own rate, under the supervision of trained teachers. The result was that, while all these children advanced in their studies much more rapidly than the average child, still the class of higher IQ outstripped the other. It was definitely superior in such complicated work as the understanding of connected passages, the addition of fractions, nature study and science, whereas the two classes were about equal in simpler work such as ordinary addition (5).

Children who enter the high school are a selected group in respect to intelligence, because those with low IQ have not been able to progress so far up the educational ladder; and the youths who graduate from the high schools are a still more select group. Many colleges try to limit the freshman class to those of superior quality, and succeed to such an extent that intelligence tests of freshmen show them to represent a very high selection from the general population.

But the correspondence between intelligence and academic achievement is less close in the secondary than in the elementary school and still less close in college. The correlation between IQ and school work goes down from .75 in the first grade to .60 in the secondary school and to .50 in college. The reason is, in part, that the college group is so highly selected that moderate success in college work is within the ability of nearly all college students who will do the work; and in part, that some students do not choose to work. Their energies may not be released at this period of their lives, or if released may be directed into some other channel. In short, besides the question of ability we have the question of motivation.

Intelligence and genius. A very high IQ is no guarantee of success in science or literature or art or politics or business. Besides the matter of motivation and of opportunity, there is the question of special aptitudes to be considered. We think of intelligence as a general "all 'round" intellectual ability, which one may have without special ability in music or writing or leadership. In fact the correlations between these special abilities and general intelligence, so far as they have been tested, are low rather than high. But it is another question whether anyone can make a great success in any special line without having high general intelligence. The great men of the past were not tested, but sometimes an estimate of their IQ in childhood can be made on the basis of their recorded performances. When we find Ralph Waldo Emerson composing a long poem at the age of ten, of which the following lines are a sample:

> "Six score and twenty thousand 'gan the fray,
> Six score alone survived that dreadful day,"

we say that the performance is beyond his years, and that his mental age must have exceeded his chronological age. From this and similar evidence, he has been estimated to have had an IQ of roughly 145. Since, unfortunately, only scanty records remain of the childhood of many great men, our best estimate of their IQ is often little better than a guess. Whenever the record is at all adequate, the indicated IQ is always over 100, and usually over 120.

As we read the early stories of great men, we are struck by other qualities besides intelligence, which must have been important in their active careers — such qualities as persistence of effort, confidence in their own powers, force of character, and ambition or the desire to excel. While all eminent men have shown high intelligence, the most eminent have not necessarily had the highest intelligence. Napoleon, by his energy and aggressiveness, combined with intelligence, made such a mark in the world — or such a dent in it — that he is still rated as the most famous man in history; yet the IQ of 135 indicated by his record in childhood is much surpassed by that of presumably lesser men, as Macaulay and John Stuart Mill, with estimated IQ in childhood of 180 to 190.

The writers and thinkers seem from the showing to have been more brilliant youngsters than the doers. The reason may be that early performances of an artistic or practical sort are not given sufficient weight in our tests and estimates (19).

Feeblemindedness. Long before the invention of intelligence tests, it was recognized that a few individuals in any sizable community were too stupid to take care of their own affairs. The most defective of all are called idiots, and those somewhat less defective are called imbeciles. The highest grade of defectives are the morons, who far outnumber the idiots and imbeciles.

Idiots do not even avoid the common dangers of life, but will put their hands into fire, walk heedlessly into deep water, or remain in the way of a motor car. They cannot learn to wash and dress themselves, and the lowest of them cannot even learn to eat or drink or take care of other bodily needs. They do not learn to talk, beyond a few monosyllables.

Imbeciles are distinguished from idiots by the fact that they do learn to avoid the common dangers of life. But they cannot learn much in the way of useful work; the lowest are incapable of any work, those somewhat higher in the scale learn to perform a few acts under supervision, and those near the upper limit of the imbecile class learn to dress, wash and feed themselves, but cannot be trusted to perform any but the simplest and briefest tasks without constant direction.

Morons, like imbeciles and idiots, are not all equal among themselves in intelligence, and the least intelligent morons are scarcely to be distinguished from the highest imbeciles. But morons can be taught to perform simple routine tasks without constant supervision. In an institution, they make the beds and run errands, and some "high-grade morons" become skillful in taking care of animals, in tending babies, in carpenter work, or in operating a lathe or sewing machine. Some progressive institutions for the feebleminded have had considerable success in releasing the high-grade morons of stable character for remunerative employment in the community; but much then depends upon a general supervision of their lives by someone who understands their limitations and has their welfare at heart. Without such a guardian, the morons are likely to make poor use of their leisure time, and to spend money foolishly; the girls are easily led into prostitution, and the boys into thievery. In general, they do not handle a broad or novel situation successfully.

The legal definition of feebleminded persons (or morons) adopted in Great Britain after a careful study is worth quoting. The feebleminded are:

> Persons in whose case there exists from birth or from an early age mental defectiveness not amounting to imbecility, yet so pronounced that they require care, supervision, and control for their own protection or for the protection of others, or, in the case of children, that they, by reason of such defectiveness, appear to be permanently incapable of receiving proper benefit from the instruction in ordinary schools.

It is significant that feeblemindedness in adults is not defined in strictly intellectual terms. The feebleminded person is unable to maintain and manage himself in the competition of the social environment. Now whether a person can manage his affairs or not depends on his intelligence but also on his physical strength and emotional stability and on the environment he has to meet. Therefore we cannot say a person is feebleminded simply because of his low score in an intelligence test. In general an idiot earns an IQ of less than 25, an imbecile less than 50, and a moron less than 70.

Early in the nineteenth century, when scientific interest was first attracted to the feebleminded, there was some hope that they could be brought up to normal intelligence by a suitable system of education. This hope has never been realized, but it has been found that the moron can be taught much of practical value to himself, provided his limitations are recognized.

Idiots and imbeciles are very often individuals who would have been perfectly normal except for some early damage to the brain, as by birth injury or encephalitis. Morons, however, are usually not pathological cases, but simply the low end of the normal distribution. There is no sharp division between the moron and the borderline case, or between the latter and the dull normal. The IQ simply shades off from average to low, as it shades off in the other direction from average to high.

Delinquency. Bad conduct may result from a disproportion between the individual's abilities and the duties which are assigned to him. If his assigned occupation is not up to his level, he may easily become heedless and mischievous. An intelligent employee on a dull routine job is apt to be a slacker and a quitter. On the other hand, anyone whose intelligence is not sufficient for the work required of him is constantly humiliated by failure, and is likely to become sullen and rebellious. A dull big boy in a school grade too high for his mental age often finds it much pleasanter out of school, and by drifting into habitual truancy makes a start towards conduct forbidden by the community, in short towards delinquency. Some criminal careers begin in just this way, and in such cases we can speak of low intelligence as a factor in antisocial conduct. But notice that it is not low intelligence by itself that produces the delinquency, but low intelligence combined with social demands (as school demands) that are unsuited to the individual's ability. When the school, perhaps by the introduction of shop work, furnishes a chance for this particular boy to succeed, his career is apt to be very different.

Since the invention of the tests, much attention has been paid to the intelligence of criminals and young delinquents. The first studies showed that a majority of delinquents were feebleminded, but with the improvement of test methods the results have changed. It now appears that, though the average intelligence of delinquents is rather low, only a small fraction can be called feebleminded. Some are average and a few rather high in intelligence, but the typical delinquent has an IQ of about 80 or 85. He is dull and obtuse rather than bright and keen. He is apt to be better in performance tests and especially in mechanical aptitude tests than in tests like the Binet or Army Alpha which make much use of language (16).

The cause of delinquency and crime is not to be found in any one factor, either low intelligence or emotional instability or poor home environment or poor neighborhood. Sometimes one factor and sometimes another appears to be more influential. An adolescent girl, badly managed at home, may drift into sex misconduct, especially if she is of low intelligence which is an economic and social handicap. A boy seeking adventure joins the gang in his rough or careless neighborhood and is drawn into various lawless exploits (2, 15). But some individuals resist environmental pressures so well that they keep a steady course in spite of many adverse factors.

Intelligence and occupation. A certain minimum intellectual ability is needed in any given occupation. In routine clerical jobs, an M.A. of 10 years is about the lowest limit for acceptable work. For higher clerical work the minimum is much higher, and it is still higher for the professions. Occasionally a boy's parents are determined that he shall become a professional man, though his IQ is only about 100. The boy may put forth the most persistent efforts, but he is unable to "make the grade." In general, one would suppose, men choose their vocations with due regard for their intellectual fitness for the work to be done; but this expectation is only partly supported by the facts. In intelligence tests professional men score highest on the average, bookkeepers and clerks rather high, mechanics fairly well, with other occupations grading off towards unskilled laborers at the bottom; but the spread of intelligence scores in each occupation is enormous. Some professional men score low and some laborers high and the most intelligent laborers surpass the least intelligent professional men. As things go today, with little expert vocational advice, many men are misfits in their chosen occupations.

Now here is a challenging fact: children grade off according to the occupations of their fathers. The children of professional men and business executives score highest in an intelligence test, the children of unskilled laborers lowest. An adjoining table shows the results obtained in several localities. The table shows the averages only, and we must bear in mind that there is a wide spread among the children from each occupational group. Bright children emerge from every occupational group, but disproportionately often from the relatively small groups in the more intellectual occupations. This has been found notably true of the children with very high IQ (19).

Why should children differ in intelligence according to the

INTELLIGENCE QUOTIENT AVERAGES OF CHILDREN WHOSE FATHERS ARE IN DIFFERENT OCCUPATIONAL GROUPS

Locality	*Northumberland, England*	*An Ohio industrial town*	*Rural New York State*
Occupation of fathers			
Professional	112	115	116
Managers	110	113	107
Clerks	110	112	
Salesmen and shopkeepers	106	109	
Foremen	103	106	109
Skilled and semi-skilled workmen	100	102	97
Common laborers	96	94	89
Agriculture, all grades	98	100	91
Whole no. children tested	13,419	4,727	6,688

The Northumberland data are from Duff and Thomson, *Brit. J. Psychol.*, 1923, 14, 192–198; the Ohio data from J. E. Collins, *J. Educ. Res.*, 1928, 17, 157–169; and the rural New York data from Haggerty and Nash, *J. Educ. Psychol.*, 1924, 15, 559–572. Similar differences have been found in Soviet Russia (M. Sirkin, 1928–29) and in Japan (H. Kirahara, 1927).

occupations of their parents? Three explanations are possible. According to the *environmental* explanation the children who grow up in intellectual homes are stimulated to intellectual activity from early childhood on and consequently develop rapidly in this respect. According to the explanation by *heredity*, parents who are naturally intelligent have children who are naturally intelligent, while the naturally stupid parents have stupid children by force of heredity.

We could choose sides and debate these two alternatives indefinitely without reaching a decision. The mere fact that children resemble their parents in intellectual activity proves nothing for either heredity or environment, since the parents who provide good heredity usually provide good environment as well. Further evidence will be postponed for a later chapter, except for the point that is made in the following table, which carries the comparison of occupational groups down to the preschool child, from two to four years of age, and shows the same gradation as appeared in the older children. If the differences are due to environment, environment gets in its work very early in a child's life.

AVERAGE IQ OF PRESCHOOL CHILDREN FROM DIFFERENT OCCUPATIONAL GROUPS

Occupational group	*Average IQ of children*
I. Professional men	116
II. Managers and proprietors	112
III. Clerks, salesmen, retailers, mechanics	108
IV. Farmers, bakers, painters, chauffeurs, barbers, waiters, etc.	105
V. Semi-skilled factory operatives, teamsters, porters, servants	104
VI. Laborers	96

These are Minneapolis children, studied by F. L. Goodenough, *The Kuhlmann-Binet Tests for Children of Preschool Age*, 1928, pp. 45–49.

The third possible explanation of the differing test scores of children from different occupational groups calls the *tests* themselves into question. Are the tests equally fair to all the groups? The professional people who prepared the tests may have drawn upon materials familiar to children of their own class and less familiar to children who grow up on the farm, for instance. This difficulty appears more plainly in the next paragraph.

Intelligence in different races. As students of psychology we have no racial prejudice and do not *care* which race is superior in intellectual ability or whether any race or nation is superior to any other. What we wish is to get at the facts without being deceived by false impressions. We cannot judge the nations by their civilizations, because no nation has created its own civilization independently and the greatest nations have been the greatest borrowers. The Greeks borrowed their alphabet from the Phoenicians and the beginnings of their art from the Egyptians. Can we use the intelligence tests for comparing nations and races?

Children of several races have been tested in American schools and what we may call the gross results are perfectly clear: white, Chinese and Japanese children score just about the same on the average, Indians and Negroes lower. Here are some results obtained in California schools by use of the man drawing test (4).

Children of American parents, average IQ =	100
Children of Chinese and Japanese parents	101
Children of Indian parents	86
Children of Negro parents	83

There are also differences between the various groups of immigrants from Europe, the Swedish and Jewish children (in American schools) surpassing the Italian and Portugese.

Our three alternative explanations are possible here again. (a) One race differs in its hereditary intellectual capacity from another. (b) All races are potentially equal, but the Indian or Negro child does not develop his full potentiality because his environment does not stimulate intellectual activity. (c) All races are not only potentially but also actually equal in intellectual activity, but their intellectual activity takes different directions, so that a test that is fair for one race (or culture) is unfair for another.

The third possibility needs to be cleared out of the way before the other two are worth discussing. And we cannot clear it out of the way at the present time. A test prepared by Americans or Europeans is almost sure to utilize materials which are poorly adapted for use with children from other cultures. So much is obvious in the case of vocabulary and other language tests, information tests, number tests of every sort, tests calling for interpretation of pictures, and paper and pencil tests. At first thought the man drawing test, the form board and the maze should be fair to children from all over the world. But there are subtle background differences.

When the tests call for quick work, they penalize children from communities where speed is of no account. When they depend on the subject's rousing his energies and doing his best, they penalize children from groups which are not accustomed to exert themselves except in serious situations, and favor children who are used to competitive games and stunts. It is impossible to say how much allowance needs to be made for these factors in comparing the test results of different races or of different communities; and therefore the results cannot be used either to prove or to disprove racial differences in intelligence (9, 10).

Geographical differences in intelligence. Within the same race, there are differences according to locality. Country children have been found to make lower scores, with an average IQ of about 90–95, than city children (1). The same three explanations are possible here as in the cases of racial and occupational differences. The city may attract the more intellectual people, or the city environment may somehow stimulate intellectual activity, or the tests may be city made. They are city tests to some extent, as can be seen in the case of this disarranged sentence which is to be put straight:

FOR THE STARTED AN WE COUNTRY EARLY AT HOUR

To many city children this sentence will recall an actual experience, while the country children will have to substitute "city" for "country" in order to have the sentence make sense. Many similar examples are to be found in the standard tests (8). The tests are good for comparing children from the same general environment, but not otherwise.

We are not entitled to conclude from the inadequacy of our tests that racial, geographical and occupational groups are equal in native ability and in intellectual activity. It is quite likely that races do differ in their hereditary gifts, and that the more intellectual occupations do attract those of superior intellectual gifts. But until our methods have been perfected we cannot reach a conclusion on these questions.

AN ANALYSIS OF INTELLIGENCE

Psychologists have been much more ready with their tests than with their definition of intelligence. One might expect them to start with an exact definition of that which they were attempting to measure. Yet we find a parallel situation in the case of weight or of electricity. We measure these without knowing what they are: in fact, physics has to measure them to find out what they are. The definition must grow out of the experiments and measurements, and not the other way around. An important principle of science is involved. It makes little difference how such a term as intelligence is defined by the "armchair psychologist." What counts is the actual procedures used in measuring intelligence, and the actual results obtained. A psychologist might say that intelligence meant for him the ability to deal effectively with novel situations, and might go on to devise tests in accordance with that definition. But his tests would have to present particular situations and would therefore measure his subjects' ability to deal with these particular situations. The intelligence which he was measuring could only be defined by discovering what his subjects did in dealing with these particular situations, and by discovering how their success here corresponded with other facts relating to the same individuals. The intelligence which we can study with the tests available must be defined as *that which the tests measure;* and to find out what the tests measure we have to examine the tests and the correlations of the test results.

Evidence from the test materials. When we examine the tests in detail and notice what the subject must do in order to pass them, and how he sometimes fails, we find several factors in success.

1. Many test items, such as the vocabulary test, require the use of knowledge previously acquired. To this extent, then, the test score depends on the ability to *learn* and remember and on a wide-awake interest in the environment.

2. The test items, however, do not usually call for mere memory, but rather for applying knowledge to a *new problem.*

3. Many items depend on "seeing the point," on picking out the *essentials* of a problem, as in the case of the form board.

4. What we may call *breadth of view* is demanded. Removing the paper wrapping before putting a piece of candy in the mouth is an instance at the level of the two-year-old. Drawing the head, trunk, arms and legs of a man in the right relations and proportions is an instance at a higher level. Placing the words of a disarranged sentence in the right order demands some ability to see the situation as a whole. One variety of breadth is the *foresight* that is needed in tracing a path through a maze without impulsively dashing into the blind alleys.

5. Many test items call for the seeing of *relationships,* as is obviously true in the analogies test, in continuing a series of numbers or symbols, in arithmetical problems, or in telling how certain objects are alike or different. The tests mentioned under the head of breadth of view could be cited here as well. Indeed, breadth of view means seeing the whole situation as a pattern of interrelated parts.

To judge by the tests themselves, then, the intelligence that is tested consists in breadth of view combined with penetration to the essentials, and in knowledge previously acquired and now utilized for solving a new problem and reaching one's goal.

Evidence from the test procedure. In order to see what demands are made upon the subject, we have to consider not only the test items but also the whole situation in which the subject is placed. The Binet tests, though conducted without haste, call for concentrated intellectual work over a period of three-quarters of an hour or more. The group tests often take fully as long and have an atmosphere of haste and competition much like that of a school examination. Even though they are so constructed as to be power tests rather than speed tests, they still demand continued intellectual work. Thus the ability to "concentrate" upon assigned tasks for a considerable time is one factor in intelligence as measured by the tests.

Students who had previously taken an intelligence test, and whose records were known, remained *without sleep* for 72 consecutive hours, at the end of which time they took a different but equivalent intelligence test; and their performance fell off 25% from their normal score. This experiment shows that *alertness* is necessary for high intelligence (11).

In order to see the effects of *active hunger* upon performance in an intelligence test, a rubber bulb was swallowed and connected with recording apparatus, so as to show when the hunger contractions of the stomach (felt as hunger pangs) occurred. The subject took a series of intelligence tests all day, without eating till evening. At the times when the hunger contractions occurred, the subject's performance improved, to slump again when the hunger contractions ceased; and after the evening meal, though the subject felt much better able to do effective work, his score failed to reach the level of his hunger periods. A second subject gave the same results. Without going so far as to conclude that hunger, per se, is a condition of intelligent behavior, we can speak again of alertness (21).

Evidence from correlations. We have said that intelligence, i.e., the intelligence that we have a scientific right to talk about, is what the intelligence tests measure. If the test scores correlated 100 percent with brain size for instance, the tests would be a perfect, even though indirect, measure of brain size, and intelligence would be to all intents and purposes identical with brain size. But since test scores correlate only +.10 or +.15 with brain size (as judged from head measurements) we conclude that intelligence and brain size are by no means identical, though somewhat related. In this way the correlations of intelligence tests with other measurements show how much intelligence has in common with other traits, and reveal what the intelligence is that we are testing. Let us therefore review these correlations.

In the first place, the self-correlation of a standard intelligence test is high, over .90. The test is a reliable measure of something characteristic of the individual. Even when individuals are retested after an interval of several years, the correlation between their scores in the first and in the second test is fairly high, say .85. Their IQs remain nearly the same. Therefore the intelligence tests measure something that is characteristic of the individual not at a certain time but over a period of years.

Intelligence scores increase with age during the growth period, and decrease with age towards the end of life. If they kept on increasing throughout life, or as long as the individual was capable of learning anything new, we might think of identifying intelligence with accumulated knowledge and skill. As the case stands, we are forced to recognize another factor in intelligence, a factor allied to physical maturity and vitality.

There is a fairly close correlation between test intelligence and school achievement. Intelligence, then, is necessary for the acquisition of language, science and mathematics. It is also necessary for success in occupations that make use of abstract ideas and symbols. It is probably necessary for eminent success in almost any line, as in art or music, in business or political leadership, in carpentry or farming or baseball.

But it is by no means the only factor in success, and the correlations between intelligence test scores and success in these practical lines would doubtless prove to be low. As the correlations with school achievement are the highest, some light could be thrown on the nature of intelligence by an analysis of the intellectual requirements of school work. The use of abstract and general ideas, the grasping of relations, and the forming of associations have been emphasized by different psychologists in their efforts to state the nature of that intelligence which is necessary in intellectual achievement and which is roughly measured by our present tests.

Is intelligence a single ability or a sum of abilities? Ever since Binet it has been customary to build an intelligence test out of many items, and to vary the character of the items. It would not be fair to construct a test for general intelligence wholly of arithmetical problems, for such a test would favor those individuals who do especially well in arithmetic and penalize those whose forte lies in vocabulary or information or following directions. Some individuals do relatively well in one sub-test, others in another. When we correlate the total scores in a general intelligence test, such as the Alpha or the Binet, with the scores in tests which are radically different in content though still calling for intelligence in a wide sense, we obtain much lower correlations. Thus the Binet test score correlates with mechanical ability to the extent of about +.20, and with a spatial relations test (an elaboration of the form board) to about the same extent. The question then is whether there are many "intelligences," with general intelligence simply a sum of them all; or whether on the contrary there is one pervasive general intelligence, along with various special abilities.

Spearman (17, 18) has long championed a general factor in intelligence, which he calls *g*, and which he believes to come into play in a great variety of performances. In any particular performance, a special ability would also come into play. There would be many of these special abilities, s_1, s_2, s_3, etc., one for each kind of performance. Some other investigators hold that it is unnecessary to assume any *g*, and that intellectual ability can best be conceived as made up of a number of special abilities, often called "group factors," because each one comes into play in a whole class of performances. Among the group factors which reveal themselves in the correlations between many varied tests are the following: ability to deal with words — verbal ability; ability to deal with numbers; ability to deal with spatial relations; ability to deal with mechanical relations; ability in music; and ability to work rapidly — a speed factor.

In face of all these group factors, Spearman still adheres to his general factor, which he conceives as a total intellectual energy, of which some individuals have much and others little, and which is expended in dealing with relationships of all sorts. The evidence on this question is of an elaborate statistical kind which lies beyond the scope of this book.

REFERENCES

1. Baldwin, B. T. *Farm children.* 1930.

2. Burt, C. L. *The young delinquent.* 1925.

3. Goodenough, F. L. *Measurement of intelligence by drawings.* 1926.

4. Goodenough, F. L. "Racial differences in the intelligence of school children." *J. Exper. Psychol.*, 1926, 9, 388–397.

5. Hollingworth, L. S., & Cobb, M. V. "Children clustering at 165 IQ and children clustering at 145 IQ compared for three years in achievement." *27th Yrbk. Nat. Soc. Educ.* Pt. 2, 1928, 3–33.

6. Jones, H. E., & Conrad, H. S. "Psychological studies of motion pictures." *Calif. Pub. Psychol.*, 1929, 3, 245–284.

7. Jones, H. E., & Conrad, H. S. "The growth and decline of intelligence." *Genet. Psychol. Monog.*, 1933, 13.

8. Jones, H. E., Conrad, H. S., & Blanchard, M. B. "Environ-

mental handicaps in mental test performance." *Calif. Pub. Psychol.*, 1932, 5, 63–99.

9. Klineberg, O. "Experimental study of speed and other factors in racial differences." *Arch. Psychol.*, 1928.

10. Klineberg, O. "A study of psychological differences between racial and national groups in Europe." *Arch. Psychol.*, 1931.

11. Laslett, H. R. "Experiments on the effects of the loss of sleep." *J. Exper. Psychol.*, 1928, 11, 370–396.

12. Miles, W. R., & Miles, C. C. "The correlation of intelligence scores and chronological age from early to late maturity." *Amer. J. Psychol.*, 1932, 44, 44–78.

13. Miles, W. R. "Age and human ability." *Psychol. Rev.*, 1933, 40, 99–123.

14. Ruger, H. A., & Stoessiger, B. "On the growth curves of certain characters in man (males)." *Ann. Eugenics*, 1927, 2, 76–110.

15. Shaw, C. R. *Delinquency areas.* 1929.

16. Slawson, J. *The delinquent boy.* 1926.

17. Spearman, C. *The abilities of man.* 1927.

18. Spearman, C. *The nature of intelligence . . .* 1923.

19. Terman, L. M., & Others. *Genetic studies of genius.* 1925, I; 1926, II.

20. Thorndike, E. L., & Others. *Adult learning.* 1928.

21. Wada, T. "An experimental study of hunger in its relation to activity." *Arch. Psychol.*, 1922.

22. Data furnished the author from the Horace Mann and Lincoln Schools of Teachers College, Columbia University.

CHAPTER V

PERSONALITY

After the psychologist has measured intelligence, there is still much that he would like to measure in order to complete his description of the individual and in order to state in what respects one individual differs from another. The chief point he would like to add is covered by the everyday term, *personality*. Here he finds a difficult field for exact study and has to admit that only a beginning has yet been made.

If some friend of yours, in applying for a position, has named you as one of his references, you will be asked by the appointing officer to tell what you know of the candidate's ability, knowledge, skill and experience, and also what you know of his personality. In replying you state, if you conscientiously can, that the candidate has a pleasing and forceful personality, that he is cheerful and even-tempered, energetic, persistent and self-reliant. Many other adjectives could be mentioned that refer to an individual's personality; and certainly these qualities are of immense importance in work, in family life and social life generally.

A moment's thought shows that these adjectives are properly adverbs. They tell how the individual behaves. One behaves in a pleasing manner, another in an irritating manner; one acts energetically, another languidly. Personality words are not names of different activities, but names of qualities of behavior. Any little act may "reveal the personality" because it shows the individual's characteristic style of action. Personality may then be defined as the *total quality of an individual's behavior*.

A *personality trait* is some particular quality of behavior, such as cheerfulness or self-reliance. The total personality would be the sum of these traits, except that it is more than a mere sum of separate qualities. It has some unity. For example, a certain person is not simply cheerful *and* self-reliant; he is cheerfully self-reliant. Another person is peevishly dependent, and another might be cheerfully dependent. The very same act may reveal several personal traits. Each individual has his own peculiar style or quality which can be only roughly characterized by naming his traits.

DESCRIBING PERSONALITY

There are two ways of attempting to picture or describe an individual's quality. One is the way of the drama, showing the individual in action in concrete incidents. This dramatic method is much used in conversation, as when someone says, "I'll tell you what kind of a man he is. When the banks all closed up, he went around quickly and borrowed money from his friends before they had learned of the closing." This method conveys vivid impressions, but does it really tell "what kind" of man is being considered? Does it do more than furnish raw material for study? The other method is analytic, and sets forth the individual's traits, as "selfish, sneaky" and so on. It is more systematic and appears more psychological, yet it is not necessarily good psychology, for it tends to neglect the individual's environment. The individual, we remember, must be studied in his environment. His behavior must be described in relation to the situation in which he is acting. If the dramatic method, which shows the situation, and the trait method, which analyzes the individual's behavior, could somehow be combined, we should be on the way to a science of personality.

Yes-no classification of individuals. Almost every trait can be paired with an opposite, as cheerful — gloomy, persist-

[illegible]

ent — yielding, kind — cruel. Can we divide people into the cheerful and the gloomy, into the persistent and the yielding, and so on with each pair of contrasted traits? Such a use of "traits" is certainly bad psychology. The distribution curve stands as a warning against classifying people into contrasting types. They scatter all the way from one extreme to its opposite, with the great mass falling along in the middle.

Dimensions of personality. Instead of speaking simply of traits and their opposites, we should speak of lines or dimensions along which individuals can be placed. Intelligence is one dimension, extending from bright to dull. The question is whether we can identify any dimensions within the field of personality. It would be easy to take a pair of opposite traits and assume them to be the poles or extremes of a dimension; we might do the same with many pairs of traits. But our various assumed traits would overlap and be, in part, the same trait under different names. Correlation provides a check here. When we have measured a sample of the population in two dimensions, a high correlation between the two sets of measurements indicates that our supposed two dimensions are largely the same. If two lines of measurement show a low correlation with each other, we know that they are the same to a slight degree. If they show a zero correlation they are separate and independent dimensions, like the latitude and longitude of geography.

Profiles. Not having a complete system of dimensions worked out by which to map an individual's characteristics, we may derive some comfort from the use of the psychological "profile," which shows to the eye in what respects the individual stands high, low or average in comparison with other people. The individual is measured or rated in various traits, and his standing in each trait is indicated by a point suitably located above or below a middle line which represents the general average of the population in question. The fact that this middle line is straight and horizontal does not mean that the average person is equal and uniform in all respects, but simply that the average is taken as the standard or base from which to measure the individual. An individual who stands a little above the average in everything is represented by a level line a little above the standard line, while an individual who stands high here and low there is represented by an irregular up-and-down line. The profile thus conveys to the eye some impression of the individual's general standing and of his evenness or unevenness of development. We cannot claim that it pictures the "total personality," for it fails to indicate how the several traits work together in the individual's behavior.

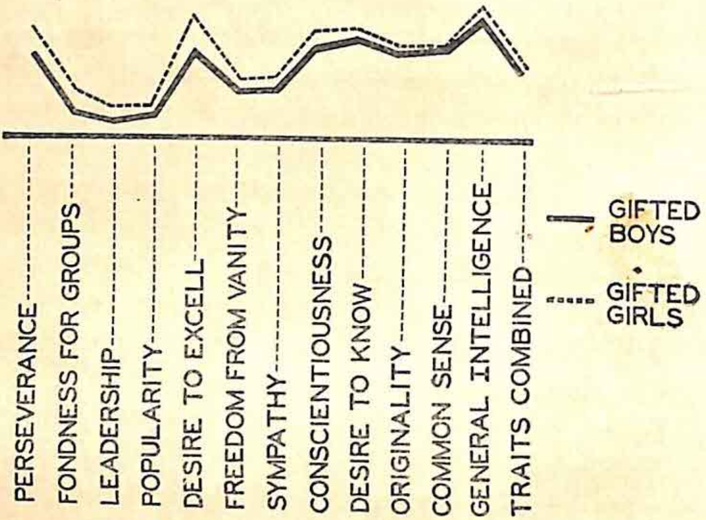


FIG. 20.— Profile for the average of 200 gifted boys and of 155 gifted girls, as rated by their teachers. (L. M. Terman and others, *Genetic studies of genius*, Stanford University Press, 1930, vol. iii, p. 188.)

PERSONALITY MEASUREMENT

The numerous methods that are being used by psychologists in their effort to secure trustworthy information regarding the individual's personal characteristics may be divided into performance tests, rating scales and questionnaires.

Performance tests in personality. The aim is to set up standard situations that will call forth genuine behavior. It is necessary to conceal the purpose of such a test, for you cannot very well tell a subject, " This is a test to discover how cheerful a disposition you have " or " This is a test to measure your willingness to cooperate." The subject would be apt to warp his behavior for the occasion. There are a few fairly successful tests in this general field. Hartshorne and May (3) succeeded in constructing tests for honesty, for cooperation, and for persistence and self control — traits of character, indeed, rather than of personality, character comprising traits in which society makes rather definite requirements, though the distinction is not sharp one. A few samples of the honesty tests follow.

A spelling test for school children was conducted in the schoolroom and consisted of rightly and wrongly spelled words, the latter to be checked by the child. The papers were collected and handed back the next day with a key by which the child was to score his own paper. To cheat he had only to change some of his pencil marks, so that cheating was easy. But meanwhile a copy of the child's original check marks had been made by the experimenters, who were thus able to detect all the cheating. In a similar test cheating was made more difficult by the use of pen instead of pencil in the checking.

A handicap gymnastic contest was arranged outside of the schoolroom. One " event " consisted in squeezing the hand dynamometer as strongly as possible. Each child was taken separately and shown how to use the dynamometer and squeezed it three times " for practice," the examiner taking a mental note of the child's best record, and then leaving the child alone with instructions to make five more attempts in rapid succession and record his results on a card. Since fatigue prevents increasing the squeeze in a rapid series of trials beyond what can be done in the first three trials, any considerable increase recorded by the subject is known to be spurious.

Among the tests for cooperation or "service" was one in which the children were presented with school kits containing pencils, erasers, rulers, etc., and were then asked to contribute, each child at his own option, parts or all of their kits for sending to some town where the children were very poor. Each child's score on this test was the amount he gave away.

In a test for persistence the examiner read the beginning of an exciting story, but stopped at the climax and passed out sheets containing the rest of the story printed with the words run together, and with capitals and spaces introduced towards the end to make deciphering increasingly difficult. The children had already had some practice in deciphering this sort of printing. The child was to mark off the words as he separated them, and his "persistence score" was the number of words he marked before giving up. The printed passage began like this:
CHARLESLIFTEDLUCILLEONHISBACK"PUTYOUR
ARMSTIGHTAROUNDMYNECK
and degenerated further along into this:
WHeNhEhIMsELFwAsaLMostexHauSTEDHEtRIEDtO
LIFThIMsELF
and finally into this:
fin ALly tAp-tAPC AME ARHYTH Month eBriD GeruNNing
fe ET

Personality tests are more feasible with preschool children than with older subjects, because of their greater naïveté; and we may expect the science of personality to be developed through study of the child.

Rating scales. Because of the difficulty of devising and administering genuine tests for personality, recourse is often had to estimates of the individual's standing in a trait or series of traits. The individual may be asked to rate himself, but usually is rated by an acquaintance. A list of traits or dimensions is provided, described as concretely as possible, and the rater assigns the individual a place in each dimension. The dimension may conveniently be represented by a straight line, on which the individual is to be located. For example an individual is to be rated in the following traits:

CHEERFULNESS

Always cheerful .... Always grouchy or gloomy

LEADERSHIP

Likes to lead and manage .... Will not or cannot take the lead

DEPENDABILITY

Very steady and dependable .... Very erratic and undependable

The average individual in any trait should be placed at the middle of the line. Raters (most of them) are likely to commit the "generosity error" by placing almost everybody near the desirable end — as if everybody could be better than average — and have to be trained out of this error before their ratings can be accepted at face value.

Another error is known as the "halo effect." If a rater has a high (or low) general opinion of an individual he is apt to rate him high (or low) in each single trait, making no discrimination.

Psychologists lay very little weight on an estimate by a single rater, but the formal rating system makes it possible to combine several ratings of the same person. The average obtained from several raters is more trustworthy, for the prejudice of one tends to be offset by the different prejudice of another.

To be of much use, either practical or scientific, a rating scale needs to be tried out and revised, and its "reliability" (p. 46) determined. The best scales, in the hands of well-trained raters who know the individual rated, have a satisfactory reliability (up to .80 or .90) and can be regarded as good measuring instruments.

Self-ratings are found on the whole to be higher than ratings by other people, but the tendency is not so strong as might be expected, and is partly balanced by a tendency to rate oneself as "about average."

The tally questionnaire. There is a special psychological type of questionnaire designed to reveal where the individual stands in a given dimension of personality. Suppose the dimension extends between the extremes, "finding trouble everywhere in life" and "finding no trouble at all in life." The questionnaire for that dimension asks as to the presence of various possible troubles, and the individual's tally or score of reported troubles indicates his position in the trouble dimension. The questionnaire can be put in the form of a check list like the following, the subject being asked to check each word which stands for a genuine trouble in his life:

Poor general health
Physical inferiority
Mysterious pains and aches
Poor appetite
Dizziness
Nervousness
Discouragement
Loneliness
Unsatisfactory friends
Hurt feelings
Bad dreams
Ennui
Being humiliated
Shyness
Self-consciousness
Lack of self-confidence
Hesitation and uncertainty
Mind-wandering
Grouchiness
Feeling miserable
Remorse
Bad luck
Unfair treatment
The dangers of life

One use of the individual's "trouble score" is obvious. If it is exceptionally large, the individual may need some confidential advice and expert assistance in adjusting himself to his environment. The scores vary enormously. A list of 223 trouble questions (14) was given to a large class of entering freshmen, and the scores ranged from a minimum of 5 to a maximum of 134, with averages of 37.3 for the men and 43.5 for the women. The average individual of this group had about 1/5 or 1/6 of all the troubles that are fairly common in the population. The individual scores clustered about the average and trailed off towards zero and still more gradually towards the other extreme. The trouble score showed a zero correlation with intelligence, but there was a slight correlation with scholarship, the larger trouble scores going with the better scholarship. Which is cause and which effect here we cannot pretend to say at present. Juvenile delinquents also give larger trouble scores, on the average, than children of the same age in the public schools (13). Individuals who are medically diagnosed as "neurotic" have often but not always a large trouble score. A neurosis consists not so much in having troubles as in "caving in" under their weight.

Questionnaires have been prepared for several different personal traits, and also for indicating the trend of the individual's interests and so assisting him in the choice of a vocation.

Another use of questionnaires is for the measurement of the individual's *attitudes* on such matters as religion, economic conservatism or radicialism, and nationalism versus internationalism. A list of questions might include the following:

Is the hope of permanent peace an idle dream?

Should our nation stand willing to arbitrate any international question?

Should our nation always be prepared for war?

Is an occasional war needed to maintain the vigor of a people?

Is it the duty of the peace-loving citizen to refuse to participate in any war?

Some of the questions are intentionally made much stronger than others. If possible they are spaced out by equal steps from one extreme to the other of the dimension in question, so that the individual's score will show how strong he is for one side or the other.

All these personality and attitude questionnaires need to be given under conditions favorable to sincere answers. There must be no motivation towards either end of the scale, for if the subject suspects that it will somehow be to his advantage to answer the questions in one way, there is nothing in the questionnaire to prevent his making any score he chooses. The trouble questionnaire is used for locating individuals who may be helped by the mental hygienist, and the attitude questionnaire for comparing different groups, for studying the effects of propaganda and for similar scientific purposes.

INTROVERSION-EXTROVERSION

Among the various " dimensions " of personality which have been suggested, none has awakened so much interest as that called by Jung (5) " introversion-extroversion." There are other pairs of names which mean essentially the same. Extroversion means interest in the environment and spontaneous participation in what is going on in the environment; whereas introversion is interest in one's own ideas and feelings and behavior that is withdrawn from the environment. The two interests are present in every normal person, and everyone shifts on occasion from one to the other. But some individuals, it was thought, are *usually* interested in the immediate environment and may be called extroverts, whereas other individuals are usually withdrawn into themselves and may be called introverts.

Is introversion-extroversion a single dimension? In the original definition no distinction was made between the social environment and the rest of the environment, and we should accordingly expect the " typical extrovert " to be interested in plants and animals and machines as well as in persons. But it was soon found that some individuals who were much absorbed in the non-human external world were not particularly good mixers socially; so that interest in nature or in machinery or even in art has come to be regarded as an introvert tendency. For the most part, the extrovert is now pictured as one who participates freely in social doings of the direct, informal sort, while the introvert participates rather little. The tally questionnaires for introversion-extroversion contain many questions of this sort:

Do you like to talk before a group of people?
Do you always try to make others agree with you?
Do you make friends easily and quickly?
Are you at ease with members of the other sex?
Do you like to take the lead in a social gathering?
Do you worry over what people think of you?
Are you somewhat suspicious of other people's motives?
Do you prefer to work alone rather than in company?
Are you easily embarrassed?
Are your feelings easily hurt?

The Yes answer to the first half of these questions is supposed to be characteristic of the extrovert, but to the last half, of the introvert. These questions all refer to social ease and confidence. But the questionnaire will probably include some quite different questions, such as:

Do you like action better than planning for action?
Do you make decisions quickly and easily?

Do you like frequent change of activity?

Do you like work that demands careful attention to detail?

Do you become much absorbed in an object that you are looking at?

Do you like to dream about the future?

The Yes answer to the first three of these is supposed to indicate extroversion, and to the last three, introversion.

It is open to doubt whether these two lists of questions have to do with the same dimension of personality. It appears rather as if one dimension were that of social interest and confidence, while the other had to do with a liking for thought, planning and close observation. There is no reason for assuming that interest in people and interest in thought and observation are incompatible. The extrovert is supposed to make the best salesman, because of his social confidence; but a dose of thought and planning would not necessarily spoil him. Artists, writers and scientists are said to be introverts; but many of them are sociable enough.

No bimodality here. Classifying everybody as either an extrovert or an introvert is bad psychology, certainly, for whenever any large group has been examined by aid of a questionnaire, a continuous gradation is found, with only a few individuals at either extreme and the great bulk about halfway between though inclining slightly to the extrovert side (4).

Relation of introversion-extroversion to other traits. The "trouble" questionnaire and that for introversion-extroversion measure very much the same thing. They have many questions in common, and the score in one correlates highly with that in the other, those who have a large trouble score tending toward the introvert side. The reason may be that so many of our troubles arise in the social sphere. Another dimension that has much in common with introversion-extroversion has been named " ascendance-submission " and is tested by questions like the following (1):

Do you stand up for your rights on all occasions?
Do you insist on good service from tradesmen?
Do you like to manage things and take responsibility?
Do you enjoy being host at a party?

The ascendant individual is one who spontaneously takes the lead in any informal face-to-face group, while the submissive individual is the " good listener " and the good follower. The correlation between ascendance and extroversion is just fair — high enough to show that the two dimensions have much in common but low enough to show that they are not identical.

The introversion-extroversion dimension seems to have no relation to intelligence, neither extroverts nor introverts surpassing the others in intelligence tests. Nor is either sex apparently more inclined than the other in either direction.

There is some indication that extroverts are superior to introverts in quickness of simple hand movements and of simple speech responses, and also in quickness of decision in simple matters (12). It has been suggested (2) that the fundamental difference vaguely revealed by studies of introversion-extroversion is a difference in promptness and facility of external motor response to a situation. One individual may react to the environment in this facile way, where another tends rather to hold back from action while he studies over the situation or savors it.

Body build and personality. Among the numerous attempts to find some connection between the individual's " constitutional type," as revealed by the proportions of his bodily structure, and his mental characteristics, the one which at the moment is attracting most attention is that of Kretschmer (6). This psychiatrist starts with a comparison of two types of insanity, called manic-depressive insanity and dementia precox.

The manic-depressive individual, normal much of the time, passes at irregular intervals into a manic, excited condition, which may last for months, and at other times into a state of depression. In the manic state, he is lively, hilarious, talkative, sometimes irascible, and always unfit for work because his attention darts from this thing to that and is never sustained. In the depressed state, the same individual is sad and brooding and anything but lively in his behavior. The dementia precox patient is withdrawn from the environment to such a degree, sometimes, that he appears perfectly oblivious to what is taking place around him. Now Kretschmer believes, in the first place, that the dementia precox patients are usually long and slender in build, while the manic-depressive patients are commonly short limbed and round. In the second place he believes that normal people tend towards either the manic-depressive or the dementia precox type of personality. The manic-depressive might be called an extreme extrovert and the dementia precox patient an extreme introvert. In the third place he suggests that even within the normal range the extrovert is inclined towards the round body and the introvert towards the slender form. These several hypotheses do not necessarily stand or fall together, and they are all speculative as yet (9).

HOW CONSISTENT IS THE INDIVIDUAL IN HIS PERSONALITY TRAITS?

When we call a person cheerful, we mean more than that he acts cheerfully in pleasant circumstances. We might allow him to lapse into gloom when everything was gloomy, but would insist on his being cheerful most of the time in order to deserve the name of a cheerful person. Any such adjective applied to an individual implies that he behaves in a certain way with some consistency. But since the environment affecting a person is anything but consistent, how can we expect consistency in his reactions?

As a matter of fact, almost no individual shows any specified "trait" with perfect consistency. No one gives all extrovert answers, or all introvert, in filling out a questionnaire. And when the same individual is carefully observed day after day in a series of situations, as in a boy's camp (8), his behavior is found to veer sometimes towards the extrovert pole and sometimes towards the introvert. The behavior seems to depend on the situation fully as much as on the individual.

Inconsistency in the honest-dishonest dimension. The studies of cheating, cooperation and self-control already mentioned led to the conclusion that the individual child was distinctly not consistent. The extensive evidence deserves careful scrutiny.

Each honesty test furnished a "cheating score" for each individual, ranging from zero when the child did no cheating up to a certain maximum. If the individual scores in two tests should correlate 100%, that would mean that the child who did the most cheating in one test did the most in the other, and that every child similarly maintained the same position from test to test. Now consider the following results.

1. The correlations were positive but low. That they were positive means that there was *some* consistency, but that they were low means that there was very little.

2. Some individual children were much more consistent than others. Some were consistently honest but scarcely anyone was consistently dishonest. That is, those who were most honest were honest in practically all the tests; but those who were most dishonest were perfectly honest part of the time. The most honest children were favored individuals, with high intelligence, from good homes and neighborhoods, and emotionally well adjusted to life. The most dishonest (cheating) children were not specially low in intelligence but suffered from poor home and neighborhood conditions.

3. Class units were more consistent than individuals. Even

in the same town and neighborhood one schoolroom class would sometimes stand out as definitely more honest than other classes. It was as if each group had developed a code or mutual understanding with regard to cheating.

4. The individual was moderately consistent in similar situations but much less so as between dissimilar tests. For example, there were several tests in which cheating meant copying answers from a key; and the correlation among these tests was +.70. There were several other tests in a gymnasium contest where cheating consisted in overstating one's performance; and the correlation among these tests was +.46. But the cross correlation between cheating in these two very different situations was only +.20. Thus the fact that a child had cheated in one "cribbing" test made it rather probable that he would cheat in another such test; while his cheating in a cribbing test afforded practically no ground for predicting whether or not he would overstate his gymnastic performance. Instead of speaking of dishonesty as a single trait one would have to regard cribbing in the schoolroom as one trait, and cheating in the gymnastic contest as another trait only slightly related to the first. Dishonesty, then, is not one general trait but breaks up into a number of more specific traits; and dishonesty is not exactly a trait of the individual, but depends upon the situation as well.

These results are not quite so shocking as they may seem at first. It is perhaps rather disturbing to find that so large a proportion of school children will cheat when they have a good chance, and it would be shocking if there were not a considerable minority who were consistently honest; but it need not shock us to learn that the cheating child occasionally lapses into honesty.

Honesty or dishonesty is certainly not a characteristic of the individual apart from the social group. Robinson Crusoe alone on an island could scarcely be either honest or dishonest.

Whether an act such as appropriating a boat or as copying numbers from one sheet of paper to another is to be called honest or dishonest depends on its social consequences and on the understanding among the persons concerned, on the group code, on the rules of the game. The individual's behavior depends on three general factors: (a) on the present situation; (b) on his past experience and training, his knowledge of the group code, and his appreciation of the social consequences of his behavior; and (c) on his more personal qualities such as sincerity, loyalty and good sportsmanship.

What is "consistency"? Similar results were obtained in the tests of cooperation and self-control: rather low correlations and little consistency. The results have been regarded as a sharp blow to the "doctrine of traits." They seem to make it unscientific to describe any individual as "very cooperative" or "moderately persistent" or "exceedingly submissive," or to assign him a place on any dimension of personality. The situation would always need to be specified. But we must notice that in these tests and ratings the individual is judged by external standards. The individual may be consistent with himself even though he cheats at one time and not at another, or though he behaves in an extrovert manner at one time and in an introvert manner in a different situation. Babies under a year old, when tested at intervals with a set of laughter-provoking situations, such as "chirruping" and "peek-a-boo," were found to show consistent differences, some laughing or smiling almost every time while others scarcely ever responded (15). Yet the most mirthful person is hardly inconsistent if in some situations he remains perfectly serious. A person is not inconsistent because he behaves differently in radically different situations. Consistency should mean like behavior in like situations. And we have to ask, What are like situations to a given individual? In order to take his own point of view, and not a purely external view, we have to ask how he sees the situation and what he is trying to get out of the situation. We have to take account of what we called in the opening chapter the individual's situation-set and goal-set.

The real question regarding consistency arises when we are *comparing one individual with others.* A is consistently more cheerful than B, though both vary with the situation, provided A is always found higher in the scale of cheerfulness. Low correlations show that individuals shift their relative positions in the scale from situation to situation, though each individual may remain consistent with his own make-up, peculiar training and present interest.

Multiple personality. All of us can be called inconsistent in the sense that we alternate between different states or conditions in which we behave very differently. In one state we notice what is about us whereas in another state we are entirely withdrawn, in one state we are active and in another state sluggish, in one state indeed we are wide awake and in another fast asleep. We behave differently when hungry and when well fed, when in a hurry and when at ease. Human personality is a many-sided affair, and different sides become prominent in different states of the individual and in his different activities. His desires pull different ways, his goals are not easily integrated into a single all-inclusive goal. Some individuals are relatively well integrated, while others appear scattered and unstable.

The lack of integration appears with dramatic vividness in those rare cases (7) which have been studied under the head of double personality. The individual passes from one state to another, showing very different traits and desires in the two states, and being unable to remember in the more lasting state what he has done in his secondary state. In the secondary state he generally remembers the primary state, but speaks of it as belonging to another person. The primary state is usually somewhat abnormal, as if the individual were not his complete self, while the secondary state is a sort of complement to the primary, though very incomplete in itself. Thus an individual who in the primary state is excessively quiet and submissive will be excessively mischievous in the secondary state. He seems to act in fractions and never as a whole.

In the celebrated Doris case (11) a little girl at the age of three years was thrown to the floor by a drunken father angry at finding her asleep in his bed. From that moment, apparently, she became an extremely quiet, industrious and conscientious child, except for intervals when she was reckless and mischievous. The sober Doris had no memory of the pranks of the mischievous Doris, though the latter knew all about the former and spoke of her with scorn. The still more celebrated Beauchamp case (10) was that of a young woman whose difficult early life had caused her to adopt an extremely religious, conscientious and self-effacing attitude, but who had brief episodes of mischievous conduct which remained quite unaccountable to her sober self. In the psychotherapist's hands, her mischievous side took shape in a secondary childish state, and a third personality appeared with the aggressive, self-seeking tendencies which are a normal component of the individual. The primary, self-effacing state had no memory of what happened during either the self-seeking or the mischievous state. The case thus developed, under treatment, into one of multiple rather than simply of double personality. The doctor's efforts were directed to putting together these three fractions into a complete person, and he apparently succeeded after years of effort, through hypnosis and by assuring the subject that she would awake from hypnosis in full possession of all her memories. Whether the essential achievement was the integration of the individual's memories, or the integration of her goals, is open to question.

REFERENCES

1. Allport, G. W., & Allport, F. H. *The A–S reaction study: a scale for measuring ascendance-submission in personality.* 1928.

2. Culler, E. "A phobic case." *Brit. J. Med. Psychol.*, 1930, 10, 46–69.

3. Hartshorne, H. & May, M. A. *Studies in deceit.* 1928. *Studies in service and self-control.* 1929. *Studies in the organization of character.* 1930. These volumes are the record of an extensive research, and consist largely of statistical evidence and the discussion of the same. For the discussion of consistency, see especially; Studies in deceit, pt. 1, pp. 377–390, pt. 2, pp. 211–214; Studies on the organization of character, pp. 287–321.

4. Heidbreder, E. "Measuring introversion and extroversion." *J. Abnor. Psychol.*, 1926, 21, 120–234.

5. Jung, C. G. *Psychological types.* 1923. This book contains the author's original definitions of introversion and extroversion, with much discussion of similar suggestions that have been made, such as Schiller's "naive" and "sentimental" attitudes, Nietzsche's "classic" and "romantic" types, and James's "tender-minded" and "tough-minded" thinkers. Jung also subdivides his introvert and extrovert types according as their activities focus upon "thinking, feeling, sensation, or intuition." His own treatment is rather "intuitive" than scientific.

6. Kretschmer, E. *Physique and character.* 1925.

7. McDougall, W. *Outlines of abnormal psychology.* 1926. Condensed accounts of cases of multiple personality, pp. 482–506.

8. Newcomb, T. M. *The consistency of certain extrovert-introvert behavior patterns in 51 problem boys.* 1929.

9. Paterson, D. G. *Physique and intellect.* 1930. See esp. pp. 231–248.

10. Prince, M. *Clinical and experimental studies in personality.* 1929.

11. Prince, W. F. *The Doris case of multiple personality.* 1915.

12. Schwegler, R. A. *A study of introvert-extrovert responses to certain situations.* 1929.

13. Slawson, J. *The delinquent boy.* 1926. A study of reform school boys, who are found to average low in "abstract verbal intelligence," such as measured by the Binet or by the paper and pencil intelligence tests, but less low in non-verbal performance tests, and

just about normal in mechanical aptitude tests. Their " trouble score " was large in comparison with school boys from the same general neighborhoods.

14. Thurston, L. L., & Thurston, T. G. "A neurotic inventory." *J. Soc. Psychol.*, 1930, 1, 3–30. The authors have taken previous questionnaires and produced an improved and comprehensive form, designed especially for use with college students as a help in finding those who need advice of a mental hygiene nature.

15. Washburn, R. W. "A study of the smiling and laughing of infants in the first year of life." *Genet. Psychol. Monog.*, 1929, 6.

Allport, G. W. & Vernon, P. E. *Studies in expressive movement.* 1933. The consistency of the individual personality as revealed in his gestures, handwriting and other motor performances.

Franz, S. I. *Persons one and three.* 1933. A case of double personality in a male subject, with integration achieved by the use of recalled experiences which served as bridges from one state to the other.

Symonds, P. M. *Diagnosing personality and conduct.* 1931. A comprehensive account of all methods used in this field, and of the results so far obtained.

CHAPTER VI

FACTORS IN PERSONALITY

Physiological and social psychology meet in the study of personality. Their meeting sometimes has the appearance of a battle, with one party laying all its stress on the biological factors, and the other on the social factors. Some will tell us that personality depends on "the glands," others that it depends on the role played by the individual in the social group. We will listen to both sides, beginning with the physiological.

The individual's *physique* is certainly a factor in his personality. The mere size of a person affects his attitude towards other people and their attitude towards him — and it is in such social relations that personality stands out most strongly. Muscular development and "looks" also have their effect on the individual's role.

Another biological factor may be spoken of as the *chemique* of the individual. It corresponds to what the ancients called *temperament*. They attempted to connect the "four temperaments" with the four great "humors" of the body. The sanguine individual, they said, had a surplus of blood, the choleric a surplus of bile, the phlegmatic a surplus of phlegm, and the melancholic a surplus of spleen. Sometimes a fifth temperament, the nervous, was admitted, resulting from a surplus of the "nerve fluid."

Though this particular theory is out of date, the possibility remains that chemical substances carried in the blood have much to do with the quality of the individual's behavior. Some of these chemical substances are introduced from outside in the food and drink or through infections. The presence of alcohol in the blood certainly alters many a person's "temperament" for the time being; and the absence of vitamins from the food and therefore from the blood leads to languor or to nervous irritability. These are substances introduced from outside; but there are also chemical substances manufactured in the body and carried around in the blood stream which have a pronounced effect on growth and behavior.

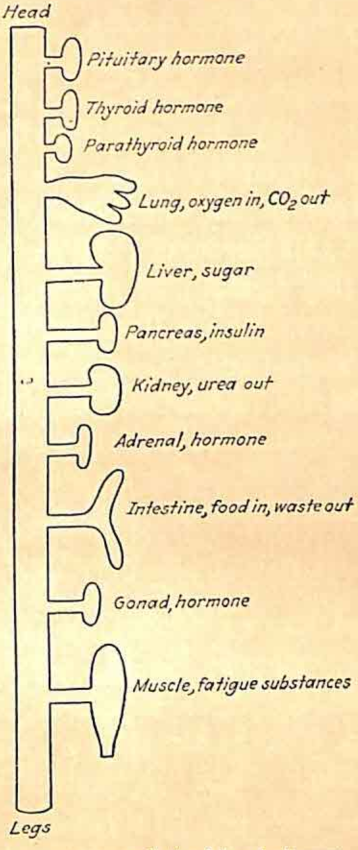


FIG. 21. — Diagrammatic view of the blood stream, with the various organs that contribute substances to it.

The blood stream as the chemical integrator of the organism. The chemical factors in personality are tied up with the circulation which is an integrator of the organism no less than the nervous system though in a different way. The circulation is a transportation system, carrying substances; the nervous system is like the telegraph and telephone, carrying messages. But neither the circulatory nor the nervous system is much like any man-made system. The transportation of substances proceeds in this way: each organ pours its product into its veins, the veins lead to the heart, the heart pumps the blood through the lungs first and then through the general circulation to every organ of the body. Each organ, then, pours its output of substances into the blood, the blood circulates indiscriminately to all the organs, and each organ helps itself to substances as they stream past. The circulation is surprisingly rapid; it may take only fifteen seconds for a substance poured into the blood stream by one organ to reach all the other organs. Thus the circulation is decidedly an integrating agency, and the condition and activity of any organ, such as the muscles or the brain, is affected by the substances that are being delivered into the blood stream by the other organs.

THE ENDOCRINE GLANDS

Hormones. These are substances produced in very minute quantities by the endocrine glands, and having potency to raise or depress the activity of various organs. An endocrine gland, or gland of internal secretion, is one that delivers its product to the blood. Take the pancreas for example. It produces two secretions: one, the pancreatic juice, is delivered into the intestine, where it acts upon the food present and takes an important part in digestion; but this is not called an internal secretion, because it does not go into the blood stream. The other product of the pancreas is *insulin*, a hormone which enables the muscles to perform their remarkable feat of burning or oxidizing sugar and so obtaining energy. Without insulin, the organism lapses into the condition of diabetes, in which sugar cannot be burned in the muscles, but accumulates in the blood, whence it is removed by the kidneys. Variations in the amount of insulin in the blood cause variations in the activity of the individual, and in his sense of well-being. An excess of insulin makes the subject feel hungry, fatigued, tremulous and anxious; and a greater excess produces severe mental distress, delirium or even unconsciousness. The mental condition is also affected in the diabetes that results from a deficiency of insulin.

The endocrine glands are small organs, not at all important in appearance, but within the past century, beginning about 1850, physiology and clinical medicine have built up an extensive science of endocrinology and have found that these apparently insignificant structures are of vital importance to the well-being of the organism. The physiologists have done their work on animals, by two main methods: by cutting out a gland and noting the results in the animal's growth, health and behavior; and by grafting portions of a gland or feeding the gland or injecting extracts of the gland. The clinicians have noted the diseases resulting from over — or under — activity of a gland and have used the glandular extracts, following the leads discovered by the physiologists. The chemists have played an increasingly important part by seeking and sometimes finding the actual hormones, the chemical substances which do the work of the glandular secretions. Some of these hormones can now be produced synthetically.

Being chemical agents, hormones affect primarily the chemical activity or "metabolism" of the body and its various organs, each hormone having specific effects. Through the metabolism they have secondary but often pronounced effects upon the growth and development of the individual and his behavior. Thus they are truly factors in personality.

The thyroid gland. This lies at the base of the neck in front of the windpipe and normally weighs less than an ounce.

Its enlargement into a "goiter" may or may not indicate anything seriously wrong. When this gland is destroyed by disease, the individual loses his former vim and alertness and sinks into a sluggish condition with bodily changes as well — a condition known as "myxedema." The skin is swollen with fluid. The muscles and brain are inert. The individual is slow, stupid, forgetful and unable to concentrate or to think or act effectively. If the gland is lost in childhood or is defective from birth, growth is retarded and stunted and intelligence is impaired. In the worst cases, called "cretins," the individual remains a dwarf, misshapen and imbecile, though placid in disposition.

One of the dramatic discoveries of endocrinology was the cure for myxedema. Beginning about 1880, surgeons sometimes removed goiters by operation. The patient was often left in the condition of myxedema, this being the case when the whole of the thyroid was removed. After a few years of experimenting it was found that simply feeding sheep's thyroid to a myxedematous person quickly restored him to his normal state, as if by magic. An extract of the gland can be taken with the same results. The cure does not, to be sure, develop new thyroid glands in the individual, but so long as he continues to receive suitable doses of the thyroid substance his condition remains normal. Even the poor little cretins can be made fairly normal children if the use of thyroid substance is begun early enough.

The thyroid hormone has been chemically identified and analyzed and found to have a composition indicated by the formula, $C_{15}\,H_{11}\,O_4\,NI_4$. It is called *thyroxin*. This substance can be used in place of the gland extract with the same good results. The carbon, hydrogen, oxygen and nitrogen in this compound are the commonest chemical elements of the body, but the iodin is peculiar to thyroxin — and, by weight, 65% of the thyroxin is iodin. The iodin is taken into the body in food and drinking water, in very small amounts, and concentrated by the thyroid gland into this chemical compound.

In regions where the iodin has almost all been leached from the ground and carried down to the sea — for example in Switzerland and in the Great Lakes region of the United States — the task of the thyroid gland is made doubly hard by the scarcity of iodin received; and in these regions thyroid deficiency is especially common.

The primary work of thyroxin is to speed up metabolism. When this hormone is deficient in amount, metabolism sinks to a low level; little oxygen is consumed by the organism and little carbon dioxide given off. When the thyroid produces an excess of its hormone, the rate of metabolism is raised above normal.

The rate of the "basal metabolism" is an important indicator of thyroid activity. "Basal" metabolism is the chemical activity that goes on in an individual who is as completely inactive and relaxed as he can be while awake. It corresponds somewhat to the "idling" of an automobile engine while the car is standing still. It takes care of breathing, the heartbeat, the maintenance of body temperature, etc. An individual whose basal metabolic rate is to be measured is taken before breakfast (so that no active digestion shall be going on), made to lie on a cot (so as to minimize muscular activity), and instructed to relax and not to worry about anything. A gas mask is adjusted over his face with an intake tube bringing him fresh air, and an outlet tube carrying his expired air off into containers so that it can later be measured and analyzed. Thus his consumption of oxygen during a certain time is measured. What is found out in this way about the individual is his basal or "idling" rate of oxidation or of consuming fuel and expending energy. His size and especially the total area of his skin through which heat escapes into the surrounding space have to be taken into account. Individuals normally differ somewhat in basal metabolic rate (most of them falling, however, within 10 percent above or below the general average or norm); but the thyroid cases show extreme deviations, down to 60 percent of the norm in some cases of myxedema and up to 160 percent of the norm in some cases of overactive thyroid (2).

When the thyroid is overactive the individual is restless, tense, irritable, worried, unstable. If he is still in the growing period, his growth is rapid, especially in length, so that he grows up to be quite the opposite from the cretin dwarf. It does not appear, however, that his mentality is raised.

Besides the extreme forms of excessive or deficient thyroid action, it is likely enough that many individuals deviate to a smaller degree up or down from the norm. Deviation large or small towards the side of excess is called "hyperthyroidism," and towards deficiency "hypothyroidism." Irritability and overactivity would characterize the "hyper" condition, sluggishness the "hypo" condition. But a diagnosis of thyroid abnormality cannot be made simply from the individual's behavior.

The parathyroids. When disease of the thyroid necessitates its removal, the surgeon has to take great care not to remove with it four little glands, about the size of buckshot, lying closely adjacent to it. If these parathyroids are removed, the subject soon gets into a condition of overexcitability, with painful muscular cramps. This dangerous condition of "tetany" can be relieved by injecting parathyroid extract. The nervous system is unduly excitable in the *absence* of the parathyroid hormone and is restored to relative calm by the presence of the hormone. So the parathyroid hormone, in contrast to that of the thyroid, is a quieter rather than an exciter. Excess of the parathyroid hormone brings on an excessively quiet condition, a condition of flabby muscles and general lassitude.

The parathyroid hormone, like the others, affects primarily the chemical processes of the organism. It somehow enables the blood to take up calcium salts from the food and also from the bones. A certain amount of calcium is needed by all the tissues. If the calcium supply of the blood falls too low, the muscles and nerves are overexcitable. In correcting parathyroid deficiency, therefore, calcium salts are given along with the parathyroid extract.

Though pronounced cases of parathyroid excess or deficiency are rare, it is believed by some endocrinologists that milder degrees are not uncommon, the " hyper " condition being characterized by lassitude and lack of interest, and the " hypo " condition by muscular tenseness and consequent fatigue, by quick, intense responses to stimuli of all sorts, and by great sensitiveness to distractions and to the criticism or opposition of other people.

The adrenal glands. These little glands were named from their location, one lying close to each kidney, though they are distinct in function from the kidneys. Each adrenal consists of an outer part, called the cortex (bark) and an inner part called the medulla (pith or marrow), the two parts being different in structure and function. Each part is an endocrine gland in its own right, and each produces a hormone.

In the early work on the adrenals, it was found (a) that these glands were essential to life, since their complete removal or destruction by disease was followed by general debility progressing gradually to death; and (b) that an extract of the glands was a powerful heart stimulant. These two findings seemed to go together logically enough, until it was found that the heart-stimulating hormone came from the medulla, whereas the part that was absolutely essential to life was the cortex. The hormone produced by the medulla is called *adrenin;* that from the adrenal cortex is called *cortin.* The part played by adrenin in the activities of the organism is now pretty well understood; but cortin is still something of a mystery.

Adrenin is one of the hormones that has been chemically analyzed and that can be produced synthetically. Its composition is $C_9H_{13}O_3N$, and its chemical structure is known. It is an exceedingly powerful hormone, very small quantities in the blood being sufficient to produce the following effects:

hastening and strengthening of the heartbeat;

constriction of the small arteries in the skin and viscera, with rise of blood pressure and forcing of the blood predominantly through the muscles and brain;

checking of the digestive activities of the stomach and intestine;

wide opening of the air passages in the lungs;

release of stored sugar from the liver;

delay of fatigue in continuously active muscles;

dilation of the pupil of the eye, rising of the hairs in furry animals, perspiration.

These effects can also be produced by activity of the "sympathetic division of the autonomic nervous system" (see p. 347). The sympathetic nerves produce these results for brief periods, while adrenin, poured out from the glands into the blood, gives these same results for comparatively long periods, up to an hour or more. Thus the adrenal medulla is an ally of the sympathetic nerves; and it is interesting that it arises, in the early development of the individual, as an outgrowth of the sympathetic nerves.

Is there any coherence among the varied effects of adrenin, listed above? Cannon (3) has shown that all these changes — increased heartbeat, open air passages, checked digestion, release of sugar from the liver, and even rising of the hairs — occur in an animal getting ready for a fight, and that they are useful in a fight and in other emergencies calling for intense muscular activity.

It is quite possible that adrenin is not poured out into the blood except in emergencies, large or small, real or imagined, and that adrenin is therefore only an emergency hormone and quite different in this respect from thyroxin. Even so, one individual might be more excitable than another; his adrenals might be more easily aroused to secrete; and his personality would have the characteristic of responding intensely to emergencies.

The adrenal *cortex* is essential to life. Its complete destruction (usually by tuberculosis) results in a fatal disease named, after its discoverer (1855), *Addison's disease.* The symptoms are: a progressive weakness and lassitude, with a continued tired feeling and disinclination to activity, loss of sex interest, loss of appetite for food, weak heart action, low basal metabolism (down by 15–20 percent), and low resistance to any sort of infectious disease. The skin darkens; the patient cannot endure external heat or cold; he often suffers from insomnia. His behavior is marked by poor judgment, irritability and lack of cooperation. These symptoms are removed by dosage with cortin, the formula for which is $C_{20}H_{30}O_5$.

Exactly how cortin tones up the organism is not yet clear. One theory is simply that it acts as a general stimulant. Another is that it regulates the amount of water in the body by enabling water to pass from the tissues into the blood. Without cortin, according to this theory, the blood becomes thick and deficient in volume and does not circulate readily. There are still other theories and the whole subject is just now under active investigation.

Overactivity of the adrenal cortex seems to be the cause of a condition marked by " virilism " or excess of masculine characteristics in either the male or the female. Occurring in a woman it causes loss of the rounded feminine contours, deepening of the voice, and growth of a beard.

The pituitary gland. This is a small body attached to the under side of the brain and lying in a pocket in the base of the skull, right in the middle of the head. Part of it originates

The complicated reproductive processes in the female, including the menstrual or estral cycle, pregnancy, child-birth and lactation, are controlled very largely by hormones produced in the ovary. But the anterior pituitary also has an important share in these processes, by virtue of its activating influence on the gonads.

Sex behavior has been better studied in animals than in man, and the results are clearer in the female animal than in the male. Each estral cycle in the female includes a briefer period of active sex behavior and a longer period of sex inactivity. In the active period an egg or ovum is discharged from the ovary towards the womb, ready for fertilization. The animal's external behavior during the active period is peculiar in two respects: she shows much more general activity than at other times, and she shows special sex activity. The general activity of the female white rat can be measured by placing her in a "squirrel cage" provided with a running wheel and with a mechanical counter to record the number of times she turns the wheel around; and it is found that she is exceedingly active during the period of "heat." Her specific sex activity is measured by placing her in a cage so constructed that she must cross an electric grid and take a shock in order to reach the male rat, and counting the number of times, within twenty minutes, that she will take this punishment in order to reach him (see p. 302). In the inactive period of her cycle she will scarcely cross the grid at all, but in the active period she crosses frequently and with little hesitation. Her behavior towards the male rat is very different in the active and in the inactive period. During the latter she fights off any male that makes advances to her, but during heat she is receptive and cooperative. The male rat, similarly tested, shows no cycle, but is much more active in crossing the grid to the female after twenty-four hours of sex deprivation than when satiated. These changes in external behavior are the result of internal chemical changes and especially of changes in the gonadal hormones.

In the human species, conditions are no doubt the same fundamentally, but much obscured by other factors of a mental and social character. The sex hormones are certainly one necessary condition for the development of sex interests. As regards personality differences, the question is whether there are " hyper " and " hypo " individuals with respect to gonadal hormones. We speak of some individuals as being over-sexed and of others as being under-sexed, and such differences might very well be due to the hormones; but real evidence on this point is scanty. In old age, as the Preacher said, " desire shall fail," and this failure also might be due to the cessation of gonadal hormones; but whether real rejuvenescence can be accomplished by dosage with these hormones remains uncertain in spite of the enthusiastic reports of some who have taken treatment; for this is a field where suggestion can have a potent influence.

The interdependence of the several endocrine glands. They act with each other and upon each other. With regard to growth, we have seen the importance of no less than four of them: the thyroid, the anterior pituitary, the adrenal cortex, and the gonads. As regards external behavior, most of the glands have an effect in the direction of increasing general activity. Diagnosis of a particular endocrine disturbance would be almost impossible from the subject's external behavior alone. For the same reason it would be useless for an individual to attempt to analyze his own personality in endocrine terms and then to go about remolding it by glandular treatment.

We are not to think of the endocrine system, nor of the whole blood-circulating system, as independent of and separate from the nervous system. There is much interaction between the two great integrating systems. When an endocrine deficiency is extreme, as in the case of myxedema, the nervous system can do little to help, but in milder "hyper" or "hypo" conditions of any gland, the individual through his nervous system has some power of compensation or adjustment, so that his personality does not wholly depend upon his glands. Besides, there is reason to believe that the glands of most people are about normal. Out of 650 young persons referred to an endocrinologist "because of outward evidences suggesting endocrine disorders," only 374, or 58 percent revealed any such disorder on careful examination, the majority of these, 279, being found to have trouble arising from the pituitary, 79 from the thyroid and 16 from hypofunction of the gonads (10). In the general youthful population the proportion of endocrine cases would obviously be much smaller than in this suspected group.

SOCIAL FACTORS IN PERSONALITY

If we hold fast to our fundamental conception of the individual's activity as being a participation in what is going on in the environment, we shall seek for factors in personality outside as well as inside the organism. Behavior at any moment depends on the individual's structure, condition, and activity in progress, and also upon the stimuli received from the environment. Moreover structure, condition and activity in progress are dependent in part upon past activity and so on past environment. If personality is the quality of an individual's behavior, it probably depends, in part, on the environment, present and past.

There is no reason for laying all the emphasis on the *social* environment. Growing up in a tropical climate may foster an easy-going disposition, and growing up in the wide open spaces, with the whole country always spread out before one's eyes, may favor a desire to see things in the large. Such possibilities have not received the scientific study that they deserve; more attention has been devoted to the social environment in relation to personality.

Codes and roles. Under these catchwords we may place the various social factors that deserve special attention. The group code (which to be sure is not usually codified) consists of the rules of conduct which the group seeks to enforce upon the individual. It has to do with manners as well as morals, and comprises the "mores" or folkways. The child picks up many of these easily and cheerfully, and where he fails to conform he is subjected to criticism, ridicule, punishment or ostracism, and usually ends by adopting the group modes of behavior.

So far as the code goes, the members of a group are expected to behave alike. But each one has his own role to play in the group, according to his age, sex and individual characteristics. The individual might be supposed to make his role, but the question before us now is whether the role does not make the individual, or at least mold him and confer upon him his personal traits. Students of the social environment have sometimes said that "personality is the role which the individual plays in his group," or that "personality is acquired in the effort to fill one's role," or at least that "personality is that which determines the individual's role." The three definitions are not identical by any means, but they all lay their emphasis on the role of the individual in the group.

The role of the child in the home. The child's role is to be little and dependent, but, no less, to grow and become more and more independent. His role is anything but static, and he comes to feel, himself, that the great thing for a child to do is to grow up. His role is also that of one who is loved and admired. But the exact definition of a particular child's role depends on his parents. Some parents do not give the child half a chance to grow up, and children come to the behavior clinics suffering from personality difficulties which are the result of injudicious handling by the parents. In one family the parents, one or both of them, are so solicitous to protect the child from every danger and hardship that they prevent his learning to do anything for himself, while in another family the child is held in such strict subjection that he, too, remains over-dependent. The spoiled child and the cowed child, in their different ways, show personality traits which can be traced back to the roles which they are filling in the home (9). The favorite child too and the unwanted child are given roles in the home which have their effect on personality.

When there are two children in the family, the home environment is distinctly not the same for both of them. Even if the parents treat them alike, each one has a different brother or sister. The older of two brothers has a younger brother as part of his environment, while the younger has an older brother — quite a different thing. Some authors, especially Alfred Adler, have seen much significance in the child's family position or *birth order*. The only child, receiving all the care, never having to share, never supplanted, might be expected to become over-dependent and at the same time tyrannical. The oldest child, after occupying the position of an only child for a few formative years, is dethroned; we might expect him to develop into a jealous person, striving to keep what he has, believing in authority and privilege; while the second child would be placed in the role of one who is always trying to catch up, an eager person and a rebel against the established order. The youngest child, the perpetual baby of the family, might be expected to assume the role of the pet who has no doubts regarding himself but looks to others for service and support. Except in large families, then, every child would be cast for an undesirable role (1).

Investigators in the behavior clinics have attempted to check these suggestions regarding family position; on the whole, no position in the family seems to be worse than any other. The same kinds of personality difficulty are found in children of every position in the family and with about equal frequency. The only child, about whom such wild statements have been made as that he usually has " a boundless egotism, is deeply hurt when he is not the center of all interest, is a complete failure at school, and constitutes the great majority of nervous children," is not as a matter of record unduly represented among the problem children referred to behavior clinics, and he presents the same variety of problems as other children, though with a slight preponderance of scholastic difficulties. Among university students the " trouble score " (see p. 94) is not larger on the average for only children than for others and shows no consistent relation to birth order (5). The clinical psychologist finds that the child's birth order is worth knowing because it suggests what his difficulties *may* be, but it is far from a sure indicator of what his difficulties actually are.

Adler fully recognizes the presence of other factors in the home which help to determine what role the child shall adopt. Much depends on the mother's skill in initiating the child into social participation and in helping him to develop a social feeling, an understanding of other people and a willingness to give and take and to play the game so as to bring pleasure to the others as well as to himself. The social feeling needs to be grafted on to the striving for superiority which, in Adler's psychology, is the fundamental motive in every individual. Thus the general role which the child can assume is that of a participating member of a group, a social being.

Freud and his followers, the psychoanalysts, have contributed to this study of the child's role and code the concept of *identification.* In place of the striving for superiority, Freud takes, for the fundamental motive of life, the individual's demand for love and pleasure, which he combines under the name of *libido,* the sex motive. The little child demands love and gratification first from his parents, and when either of them rebuffs or corrects him, he is likely to recoup himself by "identifying himself" with the parent. He seeks to assimilate his role to that of the parent, and adopts the parent's rules as his own code. Such is the origin, according to Freud, of the individual's own personal code of conduct, that is to say, of his conscience. The rules of this code are not reasoned out, and being thus more or less irrational are likely to conflict with the realities of life and to lead to quite unnecessary feelings of guilt.

These ideas of Freud and of Adler are found by students of personality to be valuable as thought provokers. They have the status of hypotheses rather than that of laws of science.

Treatment of personality difficulties. Aside from the cases which can be helped by endocrine treatment, the great aim is to lead the subject to see and adopt better ways of playing his game (or acting his role). Freud makes the subject unearth memories of childhood in the hope of bringing into the open the desires and conflicts which have distorted the personality; then socially acceptable outlets must be found for these desires. Adler seeks to discover the role which the subject is playing, to make him see it himself, and to show him how to play it better. Other mental hygienists, when working with a child, try to see his problem from his own point of view, and secure his cooperation in some plan for improving his behavior. Often the cooperation of the parents and the improvement of their attitude towards the child are essential to successful treatment.

When the child's conduct difficulties are serious, as in cases of stealing and incorrigibility, a change of home environment is necessary. Antagonisms may have developed between the child and others in the home which cannot be simply pushed aside, and the child by force of habit slips back into his old role if left in his old surroundings. He is therefore placed in a foster home, after careful study both of the child and of the home to make sure, as far as possible, that the two will fit together. Follow-up of several hundred boys and girls placed out in this way revealed great improvement of conduct in the great majority of cases (about 90 percent), except where the child's personality showed from the beginning distinctly abnormal trends. Stealing, lying and running away ceased, though not at once, and such personality traits as timidity, irritability and distrust disappeared in a favorable atmosphere. Precocious sex interest was allayed. Yet the children, after all, remained the same children. The overactive one remained overactive, though less disturbingly so; the graceful, easy-going one retained that characteristic through all the change of behavior (4).

The role of the child in the gang. In spite of the undoubted importance of the home environment as a factor in the development of his personality, the child often takes more interest in his play group, and quite possibly finds his role and acquires his code fully as much from association with his playfellows as from the home situation. Among his fellows the child escapes from the role of a dependent, and has scope for his love of adventure. Whether adventure shall mean lawlessness depends largely on the standards and facilities of the neighborhood. Boys' gangs often have a leader and an inner circle, as well as regulars and hangers-on. The activities of the gang afford a framework in which the individual boy finds his place. One may be the "brains" of the gang, one the dare-devil, and one the funny boy. One may serve as the "goat" or as the cat's-paw. The more desirable roles in the gang are won in competition. In a fighting gang the leader has to prove himself the best fighter. Personal traits such as generosity count heavily in winning the leading roles. Therefore we cannot say that the role makes the boy, though we must agree that the boy who has found his role develops in the direction of that role (11, 13).

Acquiring the group code. Another route into social psychology is by way of the study of group games. An experiment on Swiss boys (8) had to do with the rules of the game of marbles. The experimenter had boys play the game before him and quizzed them regarding the rules. The very youngest children need no rules, as each child plays entirely by himself. Somewhat older boys follow some rules in a lax way, but have no definite need of rules because they are not really playing against each other. Each boy is trying to make his marble hit the marbles in the "square" and both players can win the same game. Only later does the real competitive game appear, with its numerous rules, the purpose of which seems to be to put a premium on skill and to magnify the social aspect of the game.

The rules, when first learned by the younger boys, are regarded as sacred and authoritative. Each little boy is likely to say that his father invented the game and established its rules. The older boys are fully aware that rules exist simply for the sake of a good game and could be changed at any time by common consent of the players, provided the game would be improved. Probably few adults understand the real nature of their own group code as well as boys of twelve or thirteen see around their game of marbles.

A similar inquiry was made into children's ideas regarding lying — what lying is, why it is bad, and which of two given lies is the worst. The six-year-olds defined lying as "saying naughty words" and explained that lying was bad because it was punished. If a child, on falsely reporting to his mother that the teacher had given him a good mark, was rewarded by his mother, that was not a lie, or at least not much of one; but the boy who came home with the story of seeing a dog as big as a cow told a much worse lie, because no one would believe him.

The children of eight to ten years have switched to the opposite conception. A lie is a statement that deceives someone. It is worse to tell a lie to a child than to a grown-up because the child will believe it. Lies are bad "because if everyone lied no one would know where he was." Thus, with the older children, lying no less than the rules of a game is evaluated according to its social effects.

The logic of the younger child, who thinks a lie is bad because it is punished, may seem perverted, but it is perfectly good from the child's standpoint. He discovers the code by trying various things and finding out what goes with his elders. When he thus finds out a rule, it has for him the sanction of authority, not that of social utility. It would be interesting to see how he achieves his advance from the authoritarian to the utilitarian conception of rules. He probably does so piecemeal, since few of us can claim to have made this advance all along the line.

Adopting the "style" of the group. Besides its rules of morals and manners, the group has its more subtle nuances of behavior which come closer to what we ordinarily think of as traits of personality. Just as the individual picks up the dialect of his environment, with its drawl or twang or "Oxford accent," he takes on the group style of behavior. This type of social influence upon the individual is well seen in studies of isolated communities, such as those in the mountain "hollows" of the Blue Ridge in Virginia (12). One such small community back in the woods, without even a wagon road connecting it with the outside, had lived and inbred for a hundred years with scarcely a thought for the progress of national events, with little traffic in or out, and little moving in or out — those who did try the towns sometimes coming back with relief because they could make a living with less effort in the mountains, could "get up when they pleased and dress as they pleased." The whole tone of the place was easy-going, unambitious, fatalistic, and such was the tone of the individuals. It seems a clear case of the individual's taking up personality traits from the environment. But we must not overdraw the picture. Even in this community there were individual differences. There was the steady, industrious man, there was the relatively enterprising man, there was an ambitious boy, there was at least one young woman who rejected the community fatalism regarding a woman's predestined tally of children. Here we see the individual *resisting* the social environment. Personality cannot be a mere reflection of the environment but must depend also on the individual organism.

INTERACTION OF THE INTERNAL AND EXTERNAL FACTORS IN DEVELOPING THE PERSONALITY

What shall we say then? We have the internal or biological factors in personality, for example the endocrine hormones, and we have the environmental factors such as the code and style of the group and the role of the individual in the group. Shall we wave aside the biological factors in favor of the social, or the reverse? What we should do is to recognize the importance of both kinds of factors, but to insist that personality is not a sum of these factors, but a product of their interaction. The individual is not molded like putty, but is aroused to activity by the environment and is developed by his own activity.

Two individuals playing the same role will play it differently because of their differing constitutions. They may accomplish the same results, but do so in different ways according to their individual characteristics. Also we must remember that the individual has to win his role in the group. He is not a mere X on whom the group thrusts a role by casting lots. His already existing personality largely determines the role he shall play.

There is another point to consider. The individual passes back and forth from group to group, as between the gang and the home circle, or between the classroom and the football team, playing quite a different role in each. If personality consisted simply in playing a social role, multiple roles would mean multiple personality. Yet most of us who play two or more roles are not disintegrated. The typical case of multiple personality arises from the *refusal* of the subject to play the multiple roles that normally fall to the same individual. He tries to confine himself to the role of the serious and self-effacing person, without ever being normally aggressive or normally playful; and the roles which he refuses to play get played in special states into which he lapses against his will. By contrast the normal individual passes freely from one role to another and maintains his own unity and continuity throughout. This unity and continuity are certainly not provided by the environment but depend on the fact that the organism is itself a unit.

The continuity of personality illustrated by a case history. That the individual preserves a good measure of sameness as he grows up and comes into different environments is well brought out in the numerous case histories that have been published of neurotic and delinquent persons, "problem children" and the like. One would expect to find the same continuity in the biographies of the great, but these biographies are apt to be rather meager on the formative years. Much of psychological interest can be found in the life of the American humorist, Samuel Langhorne Clemens, better known as Mark Twain (6, 7).

Mark Twain grew up in the semifrontier town of Hannibal, Missouri, on the Mississippi River. His father, a lawyer of high character and aspirations, was a poor money-getter, and the family was always close to poverty. His mother came of a family of optimistic people, full of projects for getting ahead, and was herself a woman of great vitality, courageous and outspoken, with a peculiar, interesting drawl in her speech and the art of saying a humorous thing "with the perfect air of not knowing it to be humorous." Mark Twain resembled his mother in all these respects. She once replied to a neighbor who asked if she put any credence in the boy's astonishing tales of his adventures, "Oh yes, I know his average. I discount him ninety percent. The rest is pure gold." Sam, or Mark, was the sixth in order of seven children. He was cared for largely by negro slaves, was very fond of the stories they told, and retained a strong affection for the negro. Sympathy for the "under dog" was always one of his strong characteristics. He was the leader of a gang of boys who roamed the woods, swam in the River and explored it in "borrowed" boats. He was full of adventurous projects and practical jokes, and it was said of him that he always had a ready audience for whatever he had to say in his drawling way. One of his gang was the original of "Huckleberry Finn," the neglected son of the town drunkard, whose company was forbidden to the children of respectable families. Mark did not like school and when he was eleven, his father dying, his mother permitted him to go to work in a local printing office, where he soon learned to be an expert typesetter. Leaving home at the age of seventeen, he plied his trade in several large cities, and then suddenly, during a steamboat trip, determined to become a River pilot — the great ambition of his boyhood. He "learned the River" and piloted large steamboats between St. Louis and New Orleans for several years, until the outbreak of the Civil War put a stop to the river traffic. Soon afterwards, we find him in Nevada, then in the height of the silver boom. He dabbled in mining, optimistically, for a few months, but soon became a reporter on the leading newspaper of the region. (He had written a few sketches from time to time during his youth and early manhood.) A few years later he began to travel as a newspaper correspondent, and he ventured with much trepidation to try his hand as a lecturer. He had already, on one or two occasions, met with much success as an after-dinner speaker; and when he stood before his audience and just talked to them in his characteristic way, he carried all before him. He embodied some of his travel letters in his first book, *Innocents Abroad.* The success of this book led him to settle down, more or less, to the life of an author and man of means. He had found a wife after his own heart and was much devoted to his children. His wife became his censor and kept his writing within the bounds of respectability, from which he was prone to stray. Besides the creditable array of books and sketches which he published, there were many which were censored and left unfinished. He was always willing to take a chance on what seemed like a promising invention, and sank a fortune in a typesetting machine. He became partner in a publisning house which after rather a brilliant career went bankrupt, and then, at the age of nearly sixty, set about paying off his indebtedness by going back to the lecture platform. He suffered many disappointments and sorrows from time to time and felt them deeply but always came back to high spirits.

There is an undercurrent of serious purpose in Mark Twain's writing — to strip off cant and prejudice and see things as they really are. He was extremely critical of much that was current in religion and public life, and used to rant about the "damned human race" which was to his way of thinking inferior to the animals except in the one point of intelligence. But his readers and hearers always suspected a joke, and would burst into laughter at his most serious statements. He had made his role and was held to it. Apparently he found his role even as a boy in his gang. Certainly his behavior shows continuity in spite of the varied environments in which he lived and the varied occupations in which he engaged. One should mention also certain personality traits which had much to do with his career and which were certainly biological or constitutional: his resilience and high spirits, his great endurance (he would play billiards all night without feeling tired) and his fulness of projects and disposition to take a chance.

Such a life history brings us squarely in face of a problem around which we have been skirting for a long time — the problem of the influence of heredity on personality, on intelligence, and on behavior generally. We have been willing to recognize the importance of the "biological factor," but we have not assumed by any means that this factor is identical with heredity.

REFERENCES

1. Adler, A. *Problems in neurosis.* 1930. See esp. pp. 151–178.

2. DuBois, E. F. *Basal metabolism in health and disease.* 1927. A thorough account of the whole subject, by one of the most active contributors. Description of methods, discussion of results, and study of the scientific principles involved. The data usually obtained are the consumption of oxygen and the subject's height and weight, from which can be computed his output of heat in calories (kilogram-degrees) per hour per square meter of body surface. The basal metabolic rate, so computed, is about 50 in the first two years of childhood, sinks to 40 at the age of 20 years, to 39 at the age of 40 years and to 37 at 60 years. This is for men; the rate for women is 5–7 percent lower.

3. Cannon, W. B. *Bodily changes in pain, hunger, fear and rage.* Rev. ed. 1929.

4. Healy, W., & Others. *Reconstructing behavior in youth.* 1929.

5. Jones, H. E. "Order of birth in relation to the development of the child." *Handbk. child psychol.*, 2nd ed. 1933. 551–589.

6. Leacock, S. B. *Mark Twain.* 1932.

7. Paine, A. B. *Mark Twain,* a biography. 1912. Abridged edition, 1920.

8. Piaget, J. *The moral judgment of the child.* 1932.

9. Regensburg, J. "Studies of educational success and failure in supernormal children." *Arch. Psychol.*, 1931.

10. Rowe, A. W. "A possible endocrine factor in the behavior problems of the young." *Amer. J. Orthopsychiat.*, 1931, 1, 451–475.

11. Shaw, C. R. *Delinquency areas.* 1929.

12. Sherman, M., & Henry, T. R. *Hollow folk.* 1933.

13. Thrasher, F. M. *The gang.* 1927. See esp. pp. 328–363.

Hoskins, R. G. *The tides of life.* 1933. An interesting general review of the physiological and medical knowledge on the endocrine glands.

Mead, M. *The changing culture of an Indian tribe.* 1932. A study of a tribe on a small reservation, whose tribal institutions were breaking up due to white pressure. Loss of energy and responsibility by both the young men and the young women was an apparent result of the loss of social organization and control.

Timme, W. *Lectures on endocrinology.* 2nd ed. 1932. A brief review, addressed particularly to physicians, but useful to the student of psychology.

CHAPTER VII

HEREDITY AND ENVIRONMENT

Far from satisfying our psychological curiosity, the fact of individual differences in intelligence and personality spurs us on to trace out the causes of these differences. The question thus raised is a large scientific problem with important practical bearings. For if it is true, as some believe, that one person's superiority over another is due mostly to heredity, then the best hope for the future of mankind lies in improving the breed. If the contrary view is nearer the truth, and the main causes of individual differences lie in the environment, then it is the environment rather than the breed which needs to be improved. Shall the gardener pin his hope on careful cultivation of the soil, or on selection of the best seed?

The practical gardener knows perfectly well that both are necessary. He could never grow a superior crop from inferior seed, no matter how rich the soil, nor from even the best of seed sown in poor soil. The development of a plant is clearly a response *of* the heredity present in the seed *to* the environmental stimuli of soil, moisture and sunlight. It is equally true of the animal that development depends on both heredity and environment, and that one individual differs from another sometimes because of different heredity, sometimes because of different environment, and usually no doubt from both causes combined.

This rather dogmatic statement needs to be scrutinized in the light of the main facts in individual development, and it is not enough if we push our study back to the very birth of the individual, for both heredity and environment have exerted decisive influences during the prenatal period. We need to see the young individual's mental development against the background of early physical development as studied by the biological sciences of genetics and embryology.

ORIGIN AND EARLY DEVELOPMENT OF THE INDIVIDUAL

About nine months before birth the human individual begins his career, in the form of a one-celled organism, the fertilized ovum, which is an ovum from the mother's gonads combined with a spermatozoon from the father. In the favorable environment supplied by the mother, this microscopic individual grows and divides into two cells, into four, into eight, into many, many millions. Along with growth occurs "differentiation," which means that the cells derived from the fertilized ovum, the "daughter cells," differ among themselves, with the result that the individual develops a great variety of tissues and organs.

Amid all this multiplication and differentiation, the parts of the organism remain in union and interaction with each other, and the individual remains an integral whole, a perfect example of unity in multiplicity.

Chromosomes and genes. This bare sketch of embryonic development needs a little more detail in order to reveal the effects of heredity and environment. Within the general fluid mass or cytoplasm of any living cell is contained a small nucleus of somewhat denser material; and while the cytoplasm performs the distinctive activity of the cell — the secretion of the gland cell, the contraction of the muscle cell, or the rapid conduction of the nerve cell — it is the nucleus that takes the lead in the processes of growth. In cell division the first thing that happens is a division of the nucleus. The chromosomes, rod-like bodies which make up the nucleus, deploy in regular order and split, each forming two daughter chromosomes, one for each of the daughter cells. This splitting of the chromosomes occurs in every successive cell division, and thus the chromosomes of the fertilized ovum are reproduced in every cell of the developed organism. Every cell of the same individual possesses identical chromosomes.

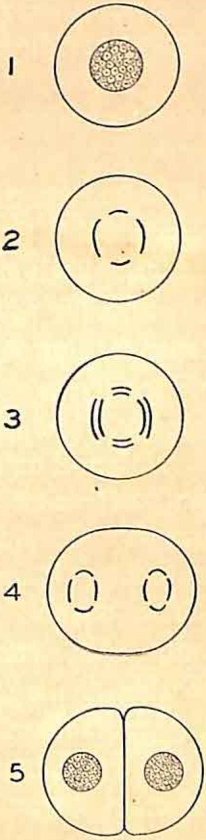


FIG. 22.—Diagram illustrating the division of chromosomes in cell division. The nucleus separates into its constituent chromosomes, here four in number. Each chromosome splits into two, one of which goes to the right hand group, the other to the left hand group. Each group then fuses into a nucleus, while the cell divides. Human cells have 48 chromosomes.

Now the chromosomes are the carriers of heredity. Half of them were brought into the fertilized ovum by the spermatozoon and the other half were present in the ovum itself prior to fertilization. From these facts we can draw two highly important inferences: (a) the individual's heredity is derived in equal measure from the maternal and paternal sides; and (b) the individual's complete heredity is present in every cell of his body.

The chromosomes are not ultimate units; each one is conceived to be an aggregation of numerous parts called "genes." The genes are too small to be seen with the microscope, but the location of single genes within the chromosome has been discovered by indirect means. Each gene carries a unit factor of heredity. The whole heredity of the individual consists of many unit factors corresponding to as many genes. That is to say, unit factors of heredity have been located in definite parts of certain chromosomes. The gene is of course a theoretical concept, like the molecule or atom or electron, with the same sort of scientific justification (7, 9).

Environmental factors in development. A hen's egg, though fertilized and containing all the heredity necessary for the development of a chick, remains quiescent while in cold storage and develops only when incubated. Environmental conditions must be favorable or the fertilized ovum will not develop at all, and if they are unusual development is apt to take an unusual course. The prime conditions to be met by the environment are protection, warmth, food, oxygen and the elimination of waste products.

It might seem, and indeed has sometimes been asserted, that heredity, however potent in the first stage of development, must become less and less important as the effects of environment accumulate. If all of heredity is present in that microscopic cell, the fertilized ovum, how can it be more than an infinitesimal factor in the individual at a later stage, as at birth, when eight pounds of material from the environment have been incorporated? The answer is that this absorbed material has not simply been added; it has been built into the organism in accordance with the organism's own hereditary characteristics. All the milk absorbed by the infant in his first year does not make him more and more milky, for he changes it chemically into human muscle, bone and brain. The chromosomes keep pace with the growth of the individual and are just as potent a factor in the later stages of development as at the very beginning.

Development is the product, not the sum, of heredity and environment. The relation of heredity and environment is not like addition but more like multiplication. The individual does not = heredity + environment, but = heredity × environment. Let heredity be represented by the base of a rectangle, and environment by its altitude. Then development, or the developed individual, is represented by the area of the rectangle, the product of base and altitude. We cannot say that the area depends more on the base or more on the altitude;

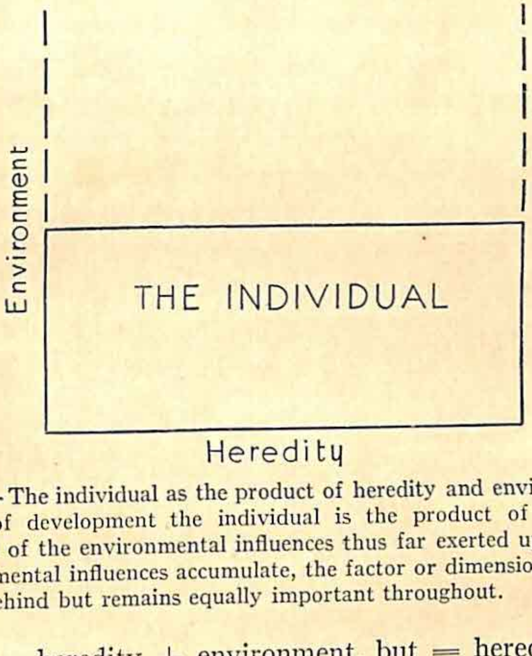


FIG. 23.—The individual as the product of heredity and environment. At any stage of development the individual is the product of his heredity (genes) and of the environmental influences thus far exerted upon him. As the environmental influences accumulate, the factor or dimension of heredity is not left behind but remains equally important throughout.

for if either should drop out there would be no area left. In the same way it is absurd to think of either heredity or environment as being more important than the other in the process of development.

The conclusion that all development depends on both heredity and environment is of importance in psychology, since what holds good of development holds good of the developed structures and of the activities of those structures.

No native traits, and yet native differences. What we have just said forces us to desist from speaking of native and acquired traits, " native " meaning due to heredity and " acquired " meaning due to environment. Every trait of an individual depends on *both* heredity and environment. This conclusion certainly seems at first thought to run counter to common sense. If one individual has blue eyes and another brown, is not the difference due to heredity and to heredity alone? If one speaks Swedish and the other Italian, is not this difference due entirely to the differing social environments in which they have grown up? Yes — but nothing we have said forbids us to speak of native *differences* and acquired differences.

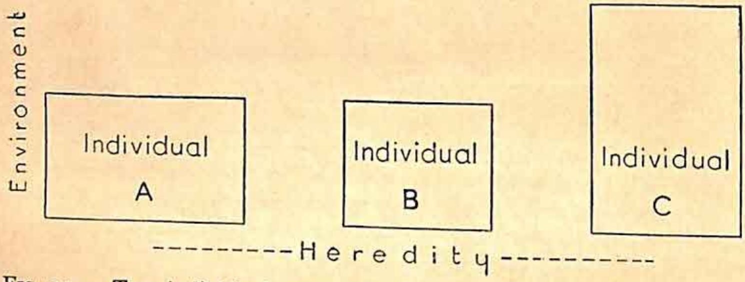


FIG. 24. — Two individuals may differ because of differing heredity or because of differing environment.

Consider the rectangle once more. While the area of any single rectangle certainly depends on both base and altitude, the difference between *two* rectangles may lie wholly in one dimension. In the same way, two individuals of the same heredity may differ because of differing environments; and two individuals exposed to identical environments may differ because of differing heredity.

EXPERIMENTS ON HEREDITY AND ENVIRONMENT

The logic of investigation is clear from what has just been said. To bring out the importance of heredity, take two individuals of different heredity and let them develop in identical environments; if they develop differently the cause must certainly be the difference in heredity. Similarly, in investigating the influence of environment, the experimenter takes individuals of identical heredity and lets them develop under different environmental conditions, so that any difference which results must be attributed to environment. These two types of experiments have been tried many times and in many ways on plants and animals.

Hybrids prove the importance of heredity in individual differences. If a male of one species is mated with a female of a different (though necessarily similar) species, the offspring is known as a hybrid. With the male parent a donkey and the female a horse (mare) the hybrid offspring has the same prenatal environment as a normal horse and should therefore be born a horse, if only environment counts. But the newborn hybrid turns out to be a mule, differing considerably from a horse. Moreover, though the postnatal environment may be the same for both, the young mule becomes more and more a mule, and the young horse (colt) more and more a horse. The difference between a mule and a horse must therefore be laid to heredity. Half of the mule's chromosomes, in fact, are donkey chromosomes and are responsible for his unhorselike peculiarities.

Cross-breeding experiments in great variety have been made by students of genetics, and the wonderful body of knowledge thus achieved from the day of Gregor Mendel, 1866, down and especially during the present century should certainly be examined by anyone who is skeptically inclined towards heredity (2, 6).

Monsters prove the importance of environment in causing individual differences. Is development what its name would seem to imply, a mere "unfolding" of characteristics which are predetermined by heredity? The negative is proved by a second type of experiment, in which an individual of normal heredity is subjected during early development to abnormal environmental conditions. There are obvious difficulties in the way of performing this type of experiment on unborn mammals, but the eggs of birds can be tampered with during incubation, and those of fishes and amphibians as they develop in the water can be heated or chilled or treated with chemicals or electric currents or rays of any kind. The result is frequently the production of a "monster," an individual differing in some striking way from the norm of the species. For example, a collection of young fish embryos, just at the stage when the eyes begin to form, is placed in the icebox for a number of hours, with the result that some of the fish become Cyclopean monsters, having a single centrally located eye (10). The difference between these monsters and normal two-eyed fish is due to a difference in environment.

Instead of saying that heredity unfolds itself, it would be nearer the truth to say that development consists in the unfolding of heredity by environment. Heredity is like a rocket lying on the shelf, a potential firework, containing within itself some of the conditions for a display, but dependent also upon external conditions. One display may differ from another because of a difference in the way the rockets are made or because of a difference in the way they are set off.

HOW DIFFERENCES IN INTELLIGENCE ARE CAUSED

The human species presents a difficult field for the student of heredity and environment. The interval from one generation to the next is so long that investigation has to advance very slowly. Breeding cannot be controlled by the investigator who is therefore forced to deal with individuals of undefined heredity, and environment can be controlled only to a slight extent for scientific purposes. The logic of investigation remains the same as in the hybrid and monster experiments, but the difficulty is to find individuals of identical heredity or individuals exposed to identical environments.

The differing heredity of siblings. Brothers and sisters — "siblings," as they are called without distinction of sex — are indeed more alike in heredity and in home environment than children taken at random from the community; but they do not have the same heredity nor the same environment.

To justify this statement with respect to heredity, we need one additional biological fact. Every human cell possesses 24 pairs of chromosomes, each pair including one from the individual's father and one from the mother. But the ovum in ripening prior to fertilization *extrudes* one chromosome from each pair — either one, just at random — and the ripe spermatozoon, similarly, contains only one of each pair. In the fertilized ovum the pairs are restored, but the whole combination is new and is practically certain to be different in any two fertilized ova even from the same mother. Therefore siblings do not have identical heredity.

Identical twins are the only exception. It sometimes happens that two individuals come from a single fertilized ovum, by a splitting of the embryo at a very early stage of development. These two individuals therefore have identical chromosomes, identical heredity. At birth such individuals usually resemble each other so closely as to be scarcely distinguishable and this resemblance persists. It extends to such details as the finger prints. These are identical, or unioval twins. "Fraternal twins" occur when two separate ova are fertilized (by two spermatozoa) at practically the same time. Coming from different fertilized ova, with different chromosomes, fraternal twins are simply siblings, with no more in common, so far as heredity is concerned, than can be expected from two children of the same parents. Fraternal twins are as often of different sexes as of the same, while identicals are always of the same sex. Even when of the same sex, fraternal twins often differ considerably in appearance and constitution.

Now the question is whether identical twins are more alike mentally than fraternals or than siblings. One convenient way of handling test data to obtain an answer to such a question is by use of the correlation coefficient (see page 42). The higher the correlation the closer the resemblance. The following table gives the net result of many investigations.

CORRELATION BETWEEN

	Identical twins	*Fraternal twins*	*Siblings*	*Unrelated individuals*
Standing height	.93 to .95	.50 to .65	.50	00
Head length	.91	.58	.50	00
IQ	.90	.63 to .70	.50 to .60	00

Much work on anatomical measurements of siblings has indicated a normal correlation of approximately .50. In intelligence tests it is probably a little closer, though not above .60. Such moderate values of the correlation coefficient mean that siblings differ considerably.

Between fraternals a little higher correlations are found than between siblings. Since fraternal twins are presumably no more alike in heredity than siblings, the higher correlations found suggest that the sum total of effective environmental influences, prenatal and postnatal combined, differs less between fraternal twins than it does between siblings born at different times.

When we come to the identicals, we find correlations that are much closer than between fraternals or siblings. To explain this result in terms of environment we should assume that the environment is much more alike for two identicals than it is for two fraternals. This assumption appears rather strained, and the explanation in terms of heredity is simpler, since we already know the hereditary difference between fraternals or siblings to be much greater than between identicals.

Another method of handling the data is simply to find the difference in IQ between the members of each pair of twins and so to obtain the average IQ difference between identicals, between fraternals, and so on. The net results to date are as follows:

AVERAGE DIFFERENCE IN IQ POINTS BETWEEN

Identical twins	*Fraternal twins*	*Siblings*	*Unrelated individuals*
4.8	8.5	12	15

The difference between identical twins is no greater than between repeated tests of the same individual. If the reader is predisposed to stress heredity, he will notice that the results obtained conform very well with the known differences in heredity (except that fraternals ought to differ as much as siblings on the basis of heredity alone). An environmentalist finds comfort in the very same table of results, for he points out that fraternals are certainly more alike in environment than other siblings, and possibly less alike in environment than identicals. We could never reach a unanimous verdict on the strength of the evidence so far presented.

Identical twins reared apart. If we could arrange to have one of a pair of identical twins reared in Russia and the other in France, we could safely predict a difference in language and probably in social and economic ideas. If one were brought up in the city and the other in the country they would certainly differ in their manners and in the kind of knowledge and skill acquired. But could we produce a difference in intelligence in any such way? Of late years attempts have been made to discover pairs of identical twins who have been separated soon after birth and reared in different families and communities. Several pairs have been found; more are needed. Here is the history of one pair (8).

Identical twin girls were adopted by different relatives at the age of five months and brought up one in the city and the other on a farm. The city girl had the more schooling and became a clerical worker and also a piano teacher. The farm girl became competent in running the farm. Neither married up to the age of 28 when they were tested.

The farm girl was found to be an inch taller than the city girl, 28 pounds heavier, more muscular and in better physical condition. She appeared to be more of a leader, more conversational, and fully as competent in general. In the intelligence tests, however, the city girl made the better scores.

	IQ obtained from	
	Stanford-Binet	Otis group test
City girl	106	111
Country girl	88.5	91

In educational tests the difference was about the same, while in a non-verbal performance test it was smaller, with the city girl still leading.

The rather large difference of about 19 points in IQ must be due to environment, and the question is whether this is a real difference in intelligence. Were the tests equally fair to city and country? — a question raised before (page 79). If we accept the usually obtained differences between city and country children as proof of genuine intellectual differences, then we can say that the country girl in this pair of identical twins was less intellectual than her city twin because of environmental factors. But if we doubt that the tests are fair to city and country, or to different races, social classes, etc., then we must discount the difference found in this pair of identical twins.

This particular pair showed a greater difference than has usually been found in identical twins reared apart. Of ten cases so far reported, six show only a trifling difference between the twins, four show rather substantial differences of 12–19 points, and the average for all is 8 points. In several cases it is difficult to judge which twin had better environmental advantages. If we should find a pair with very widely differing environments we should expect to find still larger differences in test results, but the question would remain whether we were making a fair comparison.

This subject will continue questionable until the old slogans are laid aside and new problems formulated, such as these: What kinds of difference in intellectual performances are produced by differences in environment? What environmental factors are effective in producing intellectual differences?

If identical twins reared apart can afford a measure of the environmental factor in intellectual differences, where shall we look for comparable evidence on the hereditary factor? We need to locate individuals of unequal heredity growing up in the same or equivalent environments. It is easy enough to find individuals of differing heredity but practically impossible to secure equivalent environments for them.

The differing environment of siblings. Environment covers a multitude of factors capable of affecting the individual's development. Food supply, poisons, infectious diseases may act either before or after birth. School and community are important, and the home deserves special emphasis. That the home is not the same for two brothers is clear from the fact that one has an older, the other a younger brother, a difference which may be quite important. One child may be mother's pet and the other father's; and this difference in companionship may amount to something in intellectual stimulation. Besides, it can fairly be said that *each individual creates his own environment,* in large measure, and that if two siblings differ by heredity they are sure to differ correspondingly in environment. They pick out different toys, companions, reading matter, even radio programs, and thus expose themselves to different influences. They are bound to be treated differently, for it is practically impossible to treat two individuals alike if they are unlike in intelligence or personality.

Orphanage children. Children from different parents and therefore differing more than siblings in heredity are reared under the same orphanage roof and by the same adults. If heredity counts for anything we should expect orphanage children to differ among themselves more than siblings differ. They do: whereas siblings show a correlation of about .50, orphanage mates give zero correlation in intelligence tests, and the difference between children paired at random from the same orphanage has been found to be 15 IQ points, the same as between two children chosen at random from the community. When siblings brought up in the same orphanage are compared, their IQ difference averages 12 points, which is the same as found between sibling orphans reared apart (4, 11).

In an English home which assumed the custody of children within the first year after birth, putting them out to foster mothers till the age of five or six, and then keeping them in the institution till 15–16, the records made it possible to sort out the children according to the occupation of their own parents. A control group of children was taken from a London school containing children from a wide range of parental occupations, all living at home.

AVERAGE IQ ACCORDING TO PARENTAL OCCUPATION

Parents' social status	*Children living at home*	*Children reared in institution*
Relatively high	107.5	101.7
Medium	100.4	98.6
Low	95.8	94.7
Total no. tested	439	153

The institution children were somewhat below those living in the general community — as is commonly found to be the case — but the significant fact is that these institution children though separated from their parents soon after birth nevertheless showed the typical class difference according to the occupation of their own parents (5).

The orphanage children reveal heredity as an important factor in producing intelligence differences. On the other hand, the evidence from twins shows that environment is a factor of some importance. Taken altogether, the evidence so far enables us to rule out two extreme hypotheses: first that differences in intelligence test results are due wholly to heredity, and second that they are due wholly to environment.

Evidence from foster children. Foster children deserve attention here because they are usually adopted by superior foster parents, while their own parents are not above average in intelligence or in social status. Foster children seem to be treated in general as well as own children in superior homes, and they turn out encouragingly well. But the scientific question is whether they turn out equally well with own children from superior homes. The best foster children to study are those adopted soon after birth, whose whole childhood is passed in the superior environment of their foster homes. Children who come into the hands of child-placing agencies soon after birth are commonly the children of unmarried mothers, who feel compelled to let their babies go at the earliest possible moment. Unfortunately for our purpose, little can be learned regarding the intelligence of the own fathers of most of these children. From their parentage we should expect these foster children to show an average IQ of not far from 100; while own children of their foster parents, or of parents of the same class, have an average IQ of 115.

Two large samples of such children, taken into superior foster homes within the first year after birth, have been tested, one sample in Chicago and the other in California. The IQ of the Chicago sample in later childhood averaged 104, and that of the California sample averaged 107. The difference between 100 and 104–107 would accordingly be ascribed to difference in environment, and the difference between 115 and 104–107 to difference in heredity.

The weak point in the argument is our uncertainty regarding the heredity of these children: if it was lower than estimated, environment had a greater effect than appears from the figures; but if it was a little higher, there remains no difference to attribute to environment. The only sure difference is that between foster children and own children from equally superior homes, and this difference must apparently be due to heredity. There are several other ways of utilizing the data from foster children, and some of these ways strongly indicate a real difference due to environment. But none of the indications are entirely conclusive as yet. More definite results can be expected from the continued study of foster children as well as of twins (1, 3).

From all the evidence it is fairly certain that both heredity and environment are real factors in causing individual differences in intelligence. Brain disease or injury — an environmental factor — can certainly lower the individual's intelligence to near zero. Social environmental factors in the home, school and community can raise the individual's level by a moderate amount at least. There is no evidence to indicate that any environmental influences, whether physical or social, can bring the person of low heredity up to average intelligence or personality, or the person of average heredity up to a really superior level.

SEX DIFFERENCES

Sex itself is determined by heredity. Of the 48 chromosomes of the human fertilized ovum, there is one which determines the sex of the individual. It occurs in two alternative forms, one giving male gonads, the other female gonads. Whatever differences between the sexes are dependent on the gonadal hormones are thus to be called hereditary sex differences. In addition, the sex chromosome contains other genes besides those which determine sex itself and these genes are sex-linked factors in the development of the individual, i.e., they are hereditary factors which differ from one sex to the other. We know little about them in the human species, but would expect them to amount to not over 1/48 of all hereditary factors. These sex-linked genes, plus the gonadal hormones, are responsible for the familiar sex differences in the plumage of birds and in the size and build of men and women.

Probably due to heredity is the well-known difference between men and women in muscular strength. Man surpasses not so much in endurance as in intensity of muscular action. He can squeeze harder and punch harder and run faster. This sex difference is not due simply to occupation, since it appears even in those tribes where the women do much of the hard labor. Men's muscles are somehow capable of using fuel and oxygen more rapidly, and their red blood corpuscles, which carry the oxygen from the lungs to the muscles, are ten percent more abundant than those of women.

Another sex difference comes to light in the earlier and more rapid maturing of girls. They reach sex maturity and adult stature a couple of years younger than boys, and it is probable, though not proved as yet, that they reach mental maturity earlier.

You have then a difference in size and in muscular strength favoring men and a difference in early maturity favoring women. Add to these the obvious difference in reproductive functions and you have perhaps listed all the important sex differences which are strictly hereditary. These few biological differences are responsible indirectly for considerable divergence between the occupations and achievements of men and women. When we find among primitive tribes that man is the hunter and woman the gardener, we are inclined at first to say that it is just a matter of tradition; but we soon see that this division of labor is much more economical biologically than the reverse. If this case is typical, the behavior differences which exist between men and women are neither forced by heredity nor due simply to tradition; for while the individual is following tradition, tradition is following lines of least biological resistance.

It is important to remember that sex differences in behavior or achievement are differences between the male and the female *averages*, and that the distributions overlap. Even in stature, though men average two or three inches taller, many individual women are taller than the male average. The same overlap is found in muscular strength and is still greater in the more intellectual performances. Usually the sex difference in any performance is small in comparison with the range of variation within either sex.

Sex differences in test results. In intelligence tests of the Binet type, girls show a slight superiority over boys of the same age, while in performance tests the slight advantage is with the boys. On the whole the sexes are practically equal in tested intelligence.

Memory tests give the advantage to the girls. Their learning of either connected or disconnected material is more rapid than that of boys.

Girls surpass in various language tests, such as naming all the words possible in three minutes, or saying the opposites of a given list of words. Girls seem indeed to have a definite advantage in all sorts of language activity. As babies they begin to talk a month earlier than boys, they pick up a vocabulary more rapidly, and they use longer sentences in the early years. In school they surpass the boys in language work.

Boys surpass in the tests that have been prepared to measure general information; and in school they carry away more information from geography, history and the sciences.

Boys surpass in most of the motor tests, though decidedly not in handwriting. Their superiority in managing mechanical contrivances is as marked as that of the girls in language. Can we accept these as native sex differences? There is really no good evidence on the question. We can argue that boys simply have more experience with tools and mechanical toys, but the answer is that they certainly seem to have more spontaneous interest in such things. But possibly this difference in interest is merely the result of adult steering — possibly, not probably.

We might expect to find greater differences between the sexes in personality than in intelligence, but so far as tests have gone there is not much that is definite to say. Would you expect men to be more inclined to introversion than women, or the reverse? The best indications are that the sexes do not differ in this respect.

On the whole the sexes are much more on a par mentally than our ancestors would have believed. Biology gives us no reason to expect large differences, and tests do not reveal any. But we have to leave unanswered one specially intriguing question: why are the great geniuses and producers, and the great criminals and scoundrels, still predominantly men in spite of the increased freedom of women during the past hundred years? One theory is that the male sex is inherently more variable and so presents the more extreme deviations from the average, both upwards and downwards. Another possibility is that men have more energy because of their more abundant red blood corpuscles. Both theories are speculative at the present time.

HOW UNIFORMITY OF BEHAVIOR IS PRODUCED

In spite of all the differences which we have been discussing, is it not true that people are, after all, very much alike both in structure and in behavior? They breathe alike, they pass through the same stages of growth, and within the same social group they talk and conduct themselves in much the same manner. Now if differences are due to either heredity or environment, to what are uniformities due?

We easily fall into the error of attributing certain uniformities to heredity and others to environment. Uniformity in breathing is said to be handed down by heredity, and uniformity in language by tradition. Biological uniformities are said to be transmitted by the chromosomes, and cultural uniformities by the social environment.

But this way of thinking runs counter to our previous decision that all behavior depends on *both* heredity and environment. Let us go back once more to our rectangle. Two or more rectangles cannot have the same area just because they are alike in one dimension; they must be alike in both, or else differences in one dimension must be compensated by reverse differences in the other. By the same logic, if two identical twins develop alike, they must have been exposed to practically equal environments. Uniformity in development or behavior means, not that either heredity or environment has been uniform for all the like individuals, but that both heredity and environment have been uniform, or else that the difference in heredity has been balanced by a reverse difference in environment.

This is sound logic, but the conclusion does not appear entirely convincing. It would seem that individuals of differing heredity become more and more alike when kept together in the same environment. They speak the same language, no matter what language was spoken by their parents. The reason is obvious: it is well within the native capacity of the average child to pick up the rudiments of any human language. The heredity of all normal individuals can be regarded as the same, so far as simple speech is concerned. Therefore, having *sufficiently* uniform heredity, they develop alike with respect to the rudiments of a language when exposed to the same environment. Our logic is not overthrown.

A similar example is afforded by the use of the bow and arrow in nearly all tribes and peoples, the world over, prior to the introduction of firearms. This is called an instance of social transmission, but it depends also on uniform heredity to the extent of capacity for using the bow and arrow. None but human beings have the hereditary capacity for this mode of behavior, and even the chimpanzees have not picked it up from their human neighbors.

Compensating or standardizing influences. The environment certainly makes people more alike than their heredities would lead us to expect, but the question is whether it is *equal* environment that does this. The children in a school grade were tested in October on the work to be covered during the year and were found very unequal in their knowledge. They were tested again in May on the same subject matter and found to be much more nearly equal than in October. During the interval they had all been taught by the same teacher in the same classroom, and had seemingly been exposed to the same educational environment. But this semblance of sameness disappears when we notice that some of the children mastered the required subject matter early in the year, others not till late in the year if at all. One child required two or three times as much educational environment as another in order to reach the grade standard. If it is desirable to make individuals alike in achievement, care must be taken to keep the environment at a low level so as not to afford stimulation for the brighter ones (see page 69).

The usual school enforces certain very moderate standards of achievement and prods the laggards to bring them up to the standard which is reached without prodding by the brighter children. There is no equal environment here. Prodding is a compensating influence. In many other ways the social group sets up standards which are not too high for most individuals to reach, and enforces conformity with these standards by bringing pressure to bear on those who need it. Thus unequal environmental pressure compensates in some measure for native differences and brings differing individuals to a uniform standard.

While awaiting the final decision of science on the question of human heredity and environment, the safest assumption to act upon is that heredity is an important factor. For if we should act on the assumption that everything could be accomplished by environmental control — by good cultivation of our human garden — and should allow breeding to proceed with no effort to perpetuate what appear to be the best stocks, we should lose those stocks and never be able to replace them if and when heredity should later prove to be important. If we should act on the plan of improving the human stock, and if this dependence on heredity should later prove to be misplaced, we should have lost some time but done no irreparable damage to the future of mankind. And here is another point to consider. Whether the child's intelligence and personality depend more on heredity or on very early environment, in either case they depend on the parents, and therefore the best members of each generation should become as far as possible the parents of the next generation.

REFERENCES

1. Burks, B. S. "The relative influence of nature and nurture upon mental development," *27th Yrbk. Nat. Soc. Educ.*, Pt. 1, 219–316.

2. Castle, W. E. *Genetics and eugenics.* 2d ed. 1920. This edition contains a translation of Mendel's paper.

3. Freeman, F. N. "The influence of environment on the intelligence, school achievement, and conduct of foster children." *27th Yrbk. Nat. Soc. Educ.*, Pt. 1, 103–218.

4. Hildreth, G. H. *The resemblance of siblings in intelligence and achievement.* 1925.

5. Lawrence, E. M. "An investigation into the relation between intelligence and inheritance." *Brit. J. Psychol.*, Monog. Suppl., 1931, 16.

6. Morgan, T. H. *The mechanism of Mendelian heredity.* 2nd ed. 1923.

7. Morgan, T. H. "The mechanism and laws of heredity." *Found. Exper. Psychol.*, 1929. 1–44.

8. Newman, H. H. "Mental and physical traits of identical twins reared apart." *J. Hered.*, 1932, 23, 2–18; 1933, 24, 209–214.

9. Sinnott, E. W., & Dunn, L. C. *Principles of genetics.* 1925.

10. Stockard, C. D. *The physical basis of personality.* 1931.

11. Wingfield, A. H. *Twins and orphans.* 1928.

Schwesinger, G. C. *Heredity and environment: Studies in the genesis of psychological characteristics.* 1933. A comprehensive summary of scientific studies on the effect of environment and heredity in mental development and the influence of these factors in accounting for human variability.

CHAPTER VIII

THE DEVELOPMENT OF THE INDIVIDUAL THROUGH MATURATION AND THROUGH ACTIVITY

Our study up to this point has been concerned mostly with the ways in which one individual differs from another, and with the causes of these differences. From now on we shall examine ways in which individuals are alike rather than in which they differ. The next general topic will be the process of development of the individual through growth and learning.

We begin with a pair of definitions. We distinguish maturation from development resulting from activity. Of the two, development through activity is the more familiar idea. We know, or think we know, that exercise of a muscle develops the muscle in size and strength. We know that practicing an act results in increased power and skill in the performance. These are instances of development through activity. On the other hand, we know, or think we know, that the child grows in size, that his bones become calcified, that many other changes take place in his organs and that, in short, he becomes mature, not so much by dint of exercise and practice as by a natural process of growing up. The word " natural " is really out of place here, since growth resulting from activity is also a perfectly natural process. The significant point is that there are, or may be, two causes of growth. In the case of a muscle, the activity or exercise of the muscle is one cause of its growth, while the other cause is something different, though it is not easy at the outset to specify exactly what this second cause is.

Growth is itself a kind of activity, but what is meant specifically by the activity of an organ is its peculiar function, such as contraction in the case of a muscle or secretion in the case of a gland. Our two definitions may then read:

Development through activity is the development of any organ resulting from the specific activity or functioning of that organ.

Maturation is the development of an organ towards its mature size and condition resulting from causes other than the specific activity or functioning of that organ.

We can also embody our two concepts in the form of assertions or hypotheses:

The activity or functioning of an organ results in the development of that organ, unless it is already well developed, and maintains it in good functional condition if it is already well developed; whereas prolonged inactivity results in a loss of good condition and finally in " atrophy through disuse."

The development of an organ cannot be entirely due to its activity, for it must have developed into a functional condition before it can start functioning; therefore the fundamental structure of an organ must be due to developmental processes resulting from some cause other than the activity of that organ.

These two statements sound reasonable; but it must be added that each of them has been called in question. Some psychologists doubt the reality of maturation, some doubt the reality of development through activity, and still others insist that there is no difference between the two processes.

MATURATION

It seems undeniable that an organ must develop to a certain point before it can begin to function. The heart, for example, could not start pumping blood until it had developed the structure of a workable pump. The lungs afford a still more convincing example of development preceding function. No air can possibly enter the lungs before birth to distend and exercise them, and yet we find them at birth well developed, complex structures, ready to play their part in the breathing which then begins. The further development of the lungs after birth may be the result of using them, but their prenatal development belongs squarely under our definition of maturation.

Though the child exercises his muscles before birth, the first stages in the development of a muscle belong under the head of maturation. Each muscle first makes its appearance, long before birth, as a little rudimentary structure having no contractile power. The cells of this rudiment multiply and differentiate into muscle fibers with very special structure. At the same time a nerve develops connecting the muscle with the nerve centers; and when this process of growth has gone far enough, the muscle begins to receive stimuli through its nerve from the nerve centers and to respond by contracting. Until the muscle has developed its special structure and until its connection with the nerve centers is established, it does not act and therefore its early development must be due to some cause other than its own activity.

The nature of this "other cause" can be gathered from the early development of the eye; but we had best approach this matter by a detour. We need first to make the acquaintance of a certain type of experiment much used by the embryologists. It is a third type of experiment to be set alongside of the hybrid and monster experiments of the preceding chapter.

The graft experiment. A fresh piece cut from one part of an organism can be transplanted to another part of the same organism or even grafted upon another somewhat similar organism. The graft is transplanted from a "donor" to a "host." A graft that "takes" remains alive and becomes an integral part of the host. But the cells of the graft have of course the chromosomes of the donor, and if the graft grows and its cells divide, the daughter cells and all the resulting structures have the chromosomes and heredity of the donor

The most familiar example of a graft is that of a branch cut from a superior apple tree grafted upon a sturdy wild apple tree. This branch grows with the vigor of its host but bears the fruit corresponding to its own chromosomes, the fruit of the donor tree.

Yet more instructive are grafts from one animal to another. Two young chicks were taken, one a male of a red breed, the other a female of a white breed, and pieces of skin cut from their backs were interchanged. These grafts took, and the male chick grew into a red rooster with a patch of white feathers on his back — but they were rooster's feathers; and similarly the female chick became a white hen with a patch of red hen's feathers (6). That is to say, the chromosomes of the transplanted pieces determined the breed character, white or red, of the feathers produced from their respective cells, but the sex character of these same feathers was determined by the hormones of the hosts.

Differentiation of parts within the individual is a process of maturation. It is not accounted for by heredity, for heredity is the same for all the diverse parts. It is not accounted for by the external environment, for that is normally just about the same for all parts of the embryo. It is accounted for by the interaction of parts within the organism at each successive stage of development.

Normally all the cells of the same individual have the same hereditary constitution, the same chromosomes, and yet they develop differently, one becoming a liver cell and another a nerve cell. This differentiation of parts is due to the different surroundings of different cells in the same organism. The course of development of any young cell is determined in part by the influence of the surrounding cells. This fact is well seen in the early development of the eye. The first rudiment of an eye is an outgrowth from the rudimentary brain towards the skin of the face region. This *eye-bud* evidently exerts a stimulating influence on the cells of the neighboring skin, which proceeds to thicken and forms the lens. The original eye-bud forms the retina and iris, and incorporates the lens. Other parts derived from the neighboring tissues also become incorporated into the complete eye. If the eye-bud is transplanted so as to lie under the skin of the abdomen it may induce the formation of a lens in the adjoining skin and develop a fairly complete eye in that region. Thus we see that the eye-bud, once it has made a start in differentiation, becomes a center of influence upon the surrounding, less differentiated cells, and dominates the development in a particular region at a particular time (15). Similar processes occur throughout the organism. The head gets an early start, takes the lead and dominates the development of the organism, even before the brain can exert any control through the nerves (5). Some of the hormones begin early to have an effect on development. The whole process of development is very intricate and not thoroughly understood, but it is clear that the interaction of parts within the organism is the factor which causes the various organs to take shape and become different in structure and function.

Instead of speaking of the "interaction of parts within the organism" as a factor in development, we can use if we choose the vaguer phrase "organization of the individual." This latter phrase rightly emphasizes the unity of the organism, but it tends to lead our thought back to the outgrown notion of "unfolding." It is not because the organism is a unit that it develops diverse parts. Differentiation depends upon prior differentiation. Even the fertilized ovum shows a beginning of differentiation of parts, since the upper half of it differs somewhat from the lower, perhaps by the influence of gravity. Consequently the daughter cells derived from the upper half of the fertilized ovum differ from those derived from the lower half. Thus the interaction of unlike parts is a factor in development from the beginning. The individual is a system of unlike parts which are able to interact because of the unity and continuity of the system.

Maturation is a response to stimulation received by any part of the embryo from other parts of the organism itself; and this intraorganic stimulation, differing in different regions, is the decisive factor in the differentiation of parts and so in the development of the complex system which the individual becomes during his prenatal existence.

GROWTH THROUGH ACTIVITY

The question of growth through activity is best approached by a study of muscle. The growth of a muscle as the result of repeated exercise is a matter of "common knowledge," but we learn in psychology to be wary of common knowledge and to demand definite observations in substantiation of any facts that we will accept. We certainly know that a muscle increases in *strength* when after prolonged inactivity or only light exercise it is subjected to repeated vigorous exercise. But this increase in strength is not wholly, or even mainly, the result of increased size in the muscle, for the increase in strength is much greater than can be accounted for by the relatively slight increase in thickness of the muscle. Part of the increase of strength is due to stronger nerve action upon the muscle, part is due to better circulation and oxygen supply, and part is due to the increased storage of fuel in the muscle which occurs as the result of repeated exercise (8).

Evidence for muscle growth resulting from activity. We need to make sure of this point in order to decide whether "growth through activity" is something that really occurs. There is one experiment, made in 1897 and apparently so well done that it has not needed to be repeated (10). This was a physiological experiment in which two adult dogs served as subjects. The dogs were first kept as quiet as possible in a small pen where they were supplied with abundant food. Then a long, slender muscle, the sartorius, was taken out from one thigh of each animal and carefully prepared for microscopic examination. After recovery from this operation each dog was trained in running in a tread mill. At first they ran but little, but after 20 days of training the larger dog was running the equivalent of 40–50 miles per day and this was kept up for 40 days, at the end of which time the large dog had run the equivalent of 2,000 miles and the smaller one about half as far. The sartorius was now removed from the other leg of each animal and prepared for microscopic examination and measurement in exactly the same way as the first muscle. The measurements showed that the much-exercised muscle was 50% larger in cross section than the relatively unexercised muscle. There was certainly a growth resulting from repeated activity.

Now a muscle is not a mere mass. It is composed of many slender fibers, each muscle fiber consisting of several cells fused into a unit and enclosed in a thin membrane. The large dog's sartorius, whether much exercised or not, showed in a single cross-section about 30,000 muscle fibers cut across, and the small dog's sartorius about 22,000. The number of fibers was so nearly the same in the exercised and relatively unexercised muscles as to lead to the conclusion that exercise did not increase the number of muscle fibers. But it increased the thickness of the individual fibers. The little-exercised muscle contained many very slender fibers, while in the much-exercised muscle these had become much better developed. The developing effect of exercise was not confined by any means to these slender fibers, but was most marked in their case.

To judge from this experiment, the development that results from activity differs in one important respect from the development that we call maturation. In maturation we find a multiplication of cells, while in the growth that results from activity we find no increase in the number of cells but only an increase in their size. With the increase in size goes however an increase in working power.

There is much evidence of a less direct sort in support of the conclusion that a muscle grows in size and strength as the result of repeated activity. The muscular wall of the heart becomes thicker and stronger when more work is thrown on the heart by athletic training. If the motor nerve through which any muscle receives all its normal stimuli to activity is broken in an accident, the muscle perforce lapses into an inactivity much more complete than can ever occur while the muscle is connected through this nerve with the nerve centers. A muscle thus deprived of all activity quickly deteriorates and atrophies. In the course of a few months it shrinks to a slender strand of fibrous tissue with no contractile power. But if the muscle is afforded a little exercise by electrical stimulation, it can be prevented from complete atrophy until the nerve grows out to it again, as it will if properly treated. Once the nerve connection is re-established normal activity of the muscle starts up in a small way and the muscle gradually regains its size and strength. The shrinking of a muscle that is long immobilized in a splint, with gradual recovery after the splint is removed, furnishes another example of atrophy through disuse and of growth through activity.

We have labored with this problem because of the skepticism of some psychologists regarding development through activity. Evidence that nervous tissue, as well as muscular, shows this sort of development will be presented in the next chapter.

The two processes contrasted. Both maturation and development through activity are real. Against the view that they are one and the same process, we have the fact just mentioned that activity, in the case of the muscle at least, does not lead to cell multiplication which is very pronounced in maturation. Another difference is that the maturation of any organ must proceed to a certain point before activity and its effect on growth can start. But the most important difference for psychology has to do with the stimulation in the two cases. All development is a response to stimulation. But the stimulation may reach a part of the organism from neighboring parts, as in the maturation of the eye, or it may consist in the activity of the part itself, as in the growth of the muscle resulting from exercise. A muscle that has just been active is left in a condition akin to hunger; it takes up nourishment more greedily than before.

Maturation, though dependent in a general way upon the environment, is more particularly a matter of internal relations and organization. Maturation makes the organism ready for the general kind of environment it is likely to encounter, but it does not adjust the organism to the peculiarities of the environment actually encountered. On the other hand the activity of a muscle or of a sense organ or of the brain is aroused quite definitely by the environment, and the development resulting from activity does adjust the organism to its particular environment.

DEVELOPMENT OF THE INDIVIDUAL'S ACTIVITY

The development of the organism's structure, while not lying strictly in the province of psychology, has afforded us the clearest pictures available of maturation and of growth through exercise. Activity, in which we are directly interested, depends partly on structure, other factors being the momentary condition of the organism and the stimuli received from the environment. Any activity thus depends indirectly on the maturation and previous activity of the structures used. How far it depends on the one and how far on the other is a difficult question. Any performance of an adult depends almost certainly on both.

A more pointed question arises whenever the individual's activity shows some change — whenever he does something new.

This change might have been prepared for either by maturation or by previous activity. When the child first walks, for example, it might be because his previous kicking and creeping had strengthened his muscles and nerves to the point where walking became possible, or it might be because the process of maturation had advanced to the necessary point. The new activity could emerge suddenly in either case, though the necessary structural development had been gradual.

Growth curves. Any function, whether muscular strength, keenness of eyesight, or intellectual power, develops in early

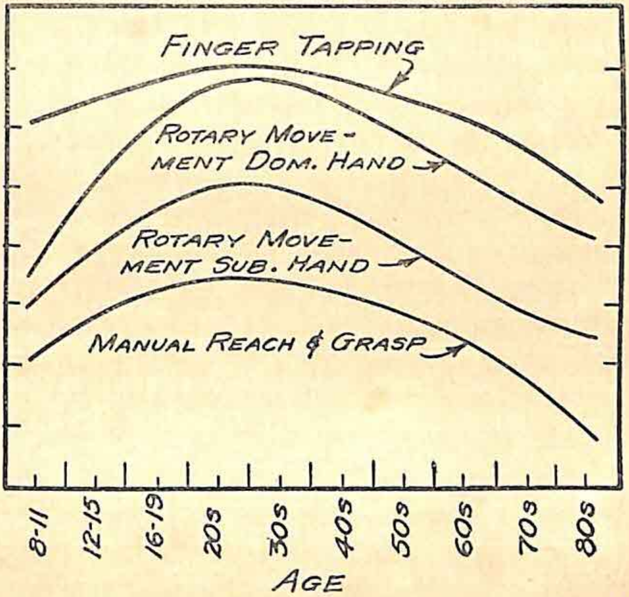


FIG. 25.—Age curves for efficiency of hand movements. (From Miles, 9.) Comparable groups were tested for the several decades of life (*cf.* p. 66). The finger tapping movement was a single up-and-down movement of the forefinger of the dominant hand. The rotary movement consisted in operating a hand drill for 10 seconds. "Manual reach and grasp" demanded quick and accurate movement. The base line in this figure is not a zero line by any means. Only the shape of the curves is significant.

life, remains near its high level for a time, and then declines with age. Examples of such age curves were given before (pp.

64–67), and a few more can be seen in the figure here reproduced. Our question is whether they give a picture of maturation or of growth through exercise. When we see the curves declining towards old age, in spite of continued activity, we can scarcely doubt that this decline is due to a biological factor, the reverse of maturation. Is it not probable, then, that the rise of the curves in the early years is an expression of maturation — in part at least? When, on the other hand, an adult of thirty, already fully matured biologically, takes up some new line of activity and makes progress in it, we can be fairly certain that this special development is the result of his activity or practice. Special practice has similar effects with younger individuals who have not yet reached full maturity. So we see that both maturation and activity are real factors in the individual's mental and behavior development (9).

Prenatal activity. That the unborn child, the "fetus," is far from entirely inactive is well known to the mother, who can feel its movements from about the middle of pregnancy on in increasing amount. More exact knowledge of the motor development of the fetus is obtained in cases of premature birth. The first muscular activity is that of the heart which starts beating at about the third week of fetal life and has the same function to perform before birth as after, since the fetus has its own blood and its own circulation. The skeletal muscles begin to act near the beginning of the third month, and during this month bending of the trunk, changes of posture, and flexion of the arms and legs, together as well as separately, have been observed. Finger and toe movements appear a little later. Weak crying, and also sucking movements, have been noticed at six months. As development proceeds the movements become stronger and more varied. A rule which holds better for the lower animals than for man is that the early movements are big, widespread muscular actions, with the finer and more sharply localized movements appearing later. Other approximate rules are (a) that strong stimuli arouse widespread muscular response while weak stimuli give more local responses, (b) that motor development advances more rapidly in the head region than further down, and (c) that whole limb movements precede movements of the fingers or toes. It is truer to say that small, localized movements are separated out of larger movements than to say that small movements develop first and are later combined into large movements; but neither statement is entirely accurate (4).

As to the senses, the eye, though it gets a very early start, is not entirely ready to function at birth, and it can scarcely receive any effective light stimuli before birth. The ear and its nerve connections are ready some weeks before birth, except that the " middle ear " (see p. 402) needs to be drained of fluid. There is some evidence of response to loud sounds before birth. The senses of taste and smell are ready long before birth but can scarcely receive any effective stimuli in the sheltered prenatal situation. The skin senses are ready before birth and may get some stimulation from the movements of the fetus. Certain internal senses, especially the muscle sense and the position-and-movement sense of the internal ear (see p. 413) are very early in their development and are certainly stimulated by movements of the fetus. Every time the fetus moves, it exercises not only its muscles but also its muscle sense and the nerve centers connected with that sense and with the muscles. In short it appears likely that prenatal activity is a factor in the development of the muscles and of the nerves and nerve centers directly connected with the muscles.

✓ The change at birth. Activity certainly increases greatly at and soon after birth. But maturation continues. Birth does not come at the same stage of development in all animals. Compare the guinea pig and the white rat, two laboratory animals that are well known and much studied. The new-born rat has no hair, it can barely crawl, does not right itself when placed on its back, and is helpless and dependent on its mother for many days. The guinea pig is born with a good coat of fur, and runs about immediately; it starts to nibble green things within a day or two. The new-born kitten is intermediate between the rat and the guinea pig in the stage of development reached at birth. The accompanying figures bring this difference out vividly. It should be noted, however, that the activities which are shown in the figure as appearing on the first day have been ready before birth and have in fact been observed in prematurely delivered animals. This is true not only of the guinea pig but to some degree even of the scratching movement of the kitten, which was not observed till the twenty-third day after birth, though rudiments of it have been observed in kittens delivered twenty days before the normal time of

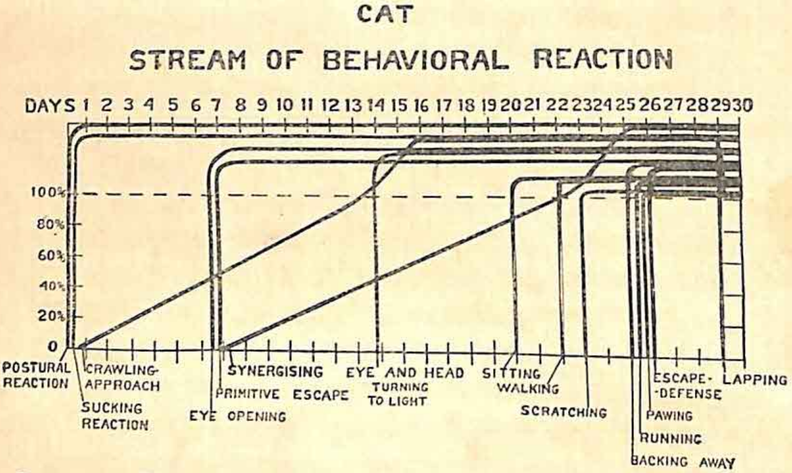


FIG. 26. — (Tilney and Kubie, 16.) The time after birth when different elements of a kitten's behavior make their appearance. An activity which comes in gradually is indicated by a sloping line. There are definite developments in the brain that account for the sudden emergence of some of these behavior patterns.

birth. But the general picture of much greater maturity in the guinea pig than in the cat at the time of birth is perfectly correct.

Similar differences are seen in different species of birds at the time of hatching. While the chick walks and feeds itself from the start, the young dove is helpless and has to be fed by the old birds. Hatching, like birth in mammals, arrives at different stages of maturation in different species.

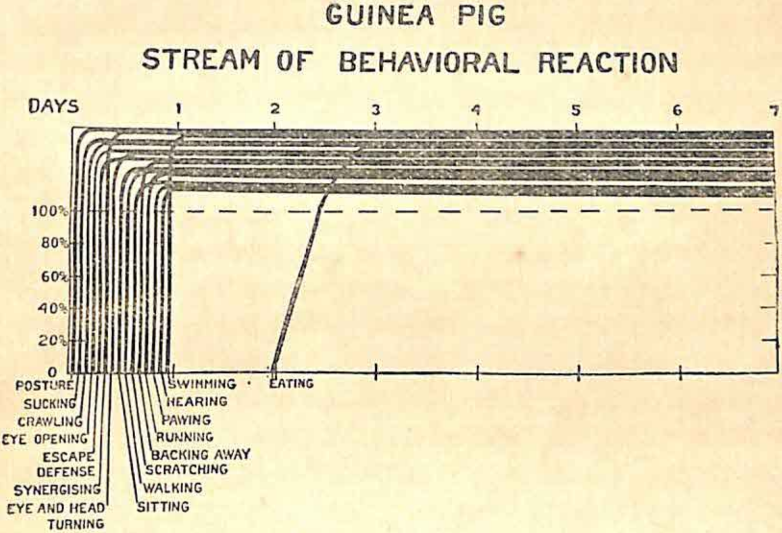


FIG. 27. — (Tilney and Kubie, 16.) The same for the guinea pig. Note that the guinea pig does many things immediately after birth which the kitten does not show for days or weeks. The guinea pig's brain is further along in its development at birth. Notice that the diagram starts at birth and credits to the first day all the acts which are ready at birth, some of which have been ready longer than others.

The human infant is born in a very immature state and requires an exceptionally long time to reach even partial independence of the mother. The whole growing period is very long in man as compared with most other animals. Yet even the new-born infant has ready quite an assortment of activities, including the elementary movements of arms and legs, trunk and head, and also the more complex movements of breathing, crying, sneezing, sucking and swallowing. Most of these are ready two months before normal birth. They depend on delicate arrangements in the nerve centers as well as upon muscular strength. Both the muscles and the nerve centers have been developed mostly by maturation, but possibly in part by prenatal exercise, as was said before.

The new activities which emerge from time to time during childhood and youth are prepared for in part by continued maturation and in part by the development of muscular, nervous and other structures through activity. When the baby advances from sucking to chewing, the change is prepared for by the maturation of the teeth. That exercise also plays a part in similar developments is shown by an experiment on the young chick. If grains are strewn before a chick one day out of the shell, it pecks at them, seizes them in its bill and swallows them; but, its aim being poor, it actually gets only a fifth of those pecked at; the next day it gets a half, in another day or so three quarters, and in about ten days it reaches a score of 85 or 90 percent. Does this improvement picture the course of maturation or the development resulting from exercise? To investigate this question, chicks were hatched in the dark, kept in a dark room, hand fed and so prevented from pecking for 2–5 days, and then brought into the light. Their pecking score for the first day in the light was no better than that of the day-old chick, but they improved more rapidly with practice. Two conclusions can be drawn. First, maturation accounts for the more rapid improvement of the chicks that were older when they started practice; the muscles and their nerve connections must have developed during the 2–5 days of delay. Second, maturation does not provide a perfect act of pecking, but exercise must be added in order to bring the act to high efficiency. Here, as often, maturation provides a mechanism that will work, and the working of the mechanism makes it stronger and more precise (2, 11).

The development of locomotion. Before attacking the question whether the human child "learns to walk," let us note some experiments on lower forms. Frog's eggs, placed in a dish of water, develop into little tadpoles which after a time begin swimming around. If a small amount of the anesthetic, chloretone, is dissolved in the water, the eggs develop normally, though the anesthetic keeps the tadpoles motionless. So far, the experiment proves that the young tadpole's structure develops by maturation without need of activity. But can this structure function well as soon as the anesthetic is washed out with plain water? For a definite test of this question, a collection of frog's eggs was divided into two groups, one of which was placed in the drugged water and the other, the "control group," in plain water. Both dishes were kept side by side under the same conditions. When the control group had begun to swim, the drug was washed out from the anesthetized tadpoles, and within half an hour they were swimming as well as the control group. In this case, then, the development of efficient locomotion depended on maturation alone and not on exercise of the developing structure (3).

An experiment on the development of flying in birds followed the same logic, though necessarily not with the same rigor. Young birds cannot be reared under constant anesthesia, but some were removed from the nest and shut up separately in little boxes that afforded no chance for stretching the wings. When their wings, nevertheless, were developed and feathered, at the usual age for commencing to fly, these boxed-up little birds were released, and the experimenter reports that they flew at once, skillfully managing wings and tail, swooping around the trees and soon disappearing from sight. It appears, then, that preparation for flying is the work of maturation and not of preliminary exercise of the immature structures used in flying (14).

These results on animals, however, should not lead us to prejudge the case of the human child. The muscular activities in which the baby engages during his first year not only help to develop his muscles and nerve centers in a general way, but also can be regarded, some of them, as definitely preliminary to walking. Stepping movements appear very soon after birth if the child is supported in an upright position. Balancing starts with some holding up of his head within the first month, and advances to good control of the head at four or five months. Next the child begins to balance his trunk while sitting, reaching good control of this posture at seven or eight months. At about ten months he stands while holding on to the furniture, and shortly afterwards begins to walk with some support. Then comes an interval of about four months before he starts to walk alone. Now this walking alone is a highly organized performance which includes stepping and the erect posture, with good balance of the head, of the trunk and of the whole body on the feet, and with a shifting of balance at every step.

There are two characteristics of the baby's progress towards walking which look more like maturation than like development through activity. First, the progress takes a regular course, all children following the same sequence with minor variations. And the sequence follows the order of maturation from the head downward — from balance of the head to balance of the trunk and finally to balance on the feet. If the child's motor development depended mostly on his activity, aroused by varying environmental stimuli, we should expect the sequence to vary from child to child. In the second place it is often though not always true that unsupported walking emerges rather suddenly, even dramatically. When the child has once taken the first few steps alone, he has the trick, evidently delights in it, and walks "all the time." This sudden emergence, though not conclusive proof of maturation, is fully in harmony with that hypothesis. Thus the systematic studies of recent years (12) throw the weight of evidence on the side of maturation rather than exercise, as the more important preparation for walking.

Voice and speech. The child passes through as regular a sequence of preliminary activities on the way to talking as on the way to walking. From birth on we find vocalization in the form of crying, which is itself a complex activity of the expiratory muscles, the larynx and the open mouth. Grunts are made during the first week or two and single syllables, like *goo* and *aak,* at about two months, followed a few weeks later by dissyllables. Baby talk which is conversational in the sense that it seems to be directed to another person, with give and take, starts at about six months, and expressive inflections and intonations at about nine months. The first word that can be recognized as imitated from adult speech occurs at about fourteen months on the average. During the second year the number of words increases first slowly and then more rapidly, and phrases and short sentences appear at about the end of this year (13).

Some children make more rapid progress than others in talking, but the sequence of preparatory acts is almost invariable. As in the case of walking, then, the indication is that maturation, rather than development through activity, is the essential factor in making children ready to learn to talk at a certain age. The child cannot utter syllables until his speech organs and nerve centers have matured to a certain point, and he cannot pick up words by imitation until his nerve centers have advanced to a further point. Undoubtedly the child's practice in uttering syllables gives him better and better control over syllables, but this is not enough to enable him to imitate words. In the same way, at a later stage, the amassing of a large vocabulary of words does not by itself enable the child to speak in relatively long and complex sentences. The maturation hypothesis does not brush aside the fact that the child must *learn* to speak, but simply means that this ability to learn is itself developed by maturation.

Puberty and sex maturity. The marked changes that occur at the beginning of adolescence — the rapid growth in height, the changing of the voice and the appearance of the beard in boys, and menstruation in girls — are certainly not the result of any activities in which the child has engaged. They are largely due to the hormones of the gonads and of the anterior pituitary, and so must be set down to the credit of maturation in the endocrine system.

Social development. Probably a "sequence" could be found in the child's social activities, and the inference drawn that his social development depends in part on maturation. Studies of the nursery school child from the age of 18 months to that of six years show that for a few months he pays little attention to the other children, then begins to make crude social contacts by pulling and pushing them, later likes to be doing the same things as some other child, and considerably later still engages in group play and cooperative enterprises. Of course it is clear here as well as in the use of language that maturation simply prepares the way for a tremendous amount of learning.

Development of intelligence. If we look for a sequence of more and more advanced intellectual performances, we can perhaps see it in the graded tests of the Binet scale. Intelligence probably matures, and the age of reaching maturity seems to be from fifteen to twenty (see pp. 64–68). Here again, maturation does not take the place of activity, but simply enables activity to proceed at the level of maturation reached at any time.

One way of experimenting on this question is to attempt to hasten development by special exercises. By coaching a child in the Binet tests, or in the man drawing test, you can improve his score and raise his apparent mental age. Now let him go for six months and test him again, and you find that he has lost the results of the coaching and is doing the test according to his true M.A. One of the best of the experiments of this sort made use of a pair of identical girl twins during their first year. Beginning at the age of 45 weeks one twin was trained in building with cubes, with help from the experimenter, while the other twin received no training of this sort and served as a "control." After six weeks of this training, ten minutes a day, the trained twin had improved considerably in manipulating the cubes and building towers with them; but the control twin, on being then tested, behaved in almost exactly the same way with the cubes and was not observably inferior to her sister. She had developed as far in cube-building by maturation alone as her sister had developed by maturation plus exercise (7).

CONCLUSIONS FROM THE CHAPTER

Several points of theoretical interest have appeared in this discussion of development.

1. Development resulting from activity was found to be a reality, but not more real nor so fundamental as development through maturation.

2. Maturation consists largely in the differentiation of parts within the individual. This differentiation is not due to either heredity or environment but to the interaction of parts already existent within the organism, which shows some differentiation of parts even at the stage of the fertilized ovum.

3. Therefore it can properly be said that the individual develops himself; and the individual's achievement in developing himself from a fertilized ovum to maturity is perhaps his greatest achievement. Certainly if one succeeded in making a man out of a fertilized ovum plus a supply of food materials one would be justified in calling it a supreme achievement.

4. The organism is an integral whole from start to finish, but it is a whole of many parts, a "unitas multiplex," and parts are of its essence no less than wholeness.

5. It is a truer picture of development, whether of structure or of behavior, to speak of parts emerging within the whole, than to speak of parts coming together to make a whole.

6. Yet neither picture is adequate; for parts are there from the start. In the development of the eye, of grafts, and of the baby's walking, we have seen parts that are relatively separate — though present within the integral organism — combining into integrated structures and performances. The organism as a whole is to be thought of as a continuous system within which the interaction of parts is easy.

7. Maturation provides structures which are capable of functioning, but which require exercise, activity, to bring them into prime working condition. Maturation prepares the way for learning. When maturation has advanced to a certain stage, activity and learning on the corresponding level become possible. Learning starts in a small way before birth, probably, and takes place to an enormous extent in the postnatal period of continued maturation, and on to the end of life after maturation has done its work. If man has any achievement comparable with his self-maturation from the egg, it is found in the development which he accomplishes through activity and learning.

REFERENCES

1. Bainbridge, F. A. *The physiology of muscular exercise.* 3d ed., rewritten by A. V. Bock & D. B. Dill. 1931.

2. Bird, C. "Maturation and practice: their effects upon the feeding reactions of chicks." *J. Comp. Psychol.*, 1933, 16, 343–366.

3. Carmichael, L. "A further experimental study of the development of behavior." *Psychol. Rev.*, 1928, 35, 253–260.

4. Carmichael, L. "Origin and prenatal growth of behavior." *Handbk. Child Psychol.*, 2d ed. 1933. 31–159.

5. Child, C. M. *Physiological foundations of behavior.* 1924.

6. Danforth, C. H., & Foster, F. "Skin transplantation as a means of studying genetic and endocrine factors in the fowl." *J. Exper. Zool.*, 1929, 52, 443–470.

7. Gesell, A., & Thompson, H. "Learning and growth in identical twins." *Genet. Psychol. Monog.*, 1929, 6.

8. Gould, A. G., & Dye, J. A. *Exercise and its physiology.* 1932. esp. pp. 371–391.

9. Miles, W. R. "Measures of certain human abilities throughout the life span." *Proc. Nat. Acad. Sci.*, 1931, 17, 627–633.

10. Morpurgo, B. "Ueber Activitäts-Hypertrophie der willkürlichen Muskeln." *Arch. path. Anat.*, 1897, 150, 522–554.

11. Shepard, J. F., & Breed, F. S. "Maturation and use in the development of an instinct." *J. Anim. Beh.*, 1913, 3, 274–285.

12. Shirley, M. M. *The first two years.* Vol. I. *Postural and locomotor development.* 1931.

13. The same, Vol. II. *Intellectual development.* 1932.

14. Spalding, D. A. "Instinct: with original observations on young animals." Macmillan's Mag., 1873, 27, 282–293; reprinted in *Pop. Sci. Mo.*, 1902, 61, 126–142.

15. Spemann, H. "Some factors of animal development." *Brit. J. Exper. Zool.*, 1925, 2, 493–504.

16. Tilney, F., & Kubie, L. S. "Behavior in its relation to the development of the brain." *N. Y. Neur. Instit. Bull.*, 1931, 1, esp. pp. 235–236.

CHAPTER IX

THE NERVOUS SYSTEM

The unity of the organism, for all its diversity of parts, is maintained by several integrating systems. First of all, identical chromosomes mark every cell with the individual's private stamp. The circulation, a second integrating system, brings to every organ the same food materials, hormones, poisons (if present) and waste products, and thus supplies to all the cells a uniform chemical medium in which they live. With the same heredity and the same chemical medium affecting all parts, and with the constant interaction of the parts in the continuous organic whole, the organism develops and behaves as a consistent unit.

THE NERVES

But the organism would be a sluggish hulking sort of unit without the third integrating system consisting of rapidly conducting nerves. A general view of the nervous system shows nerves ramifying to every nook and corner of the body. Every part has a line of communication with every other. But a second glance shows that no part is directly connected with any other, for the nerves radiate from the brain and spinal cord. These two central masses are continuous with each other and constitute the nerve center, and all the nerves lead to or from this big general center.

The sensory nerves conduct into the center and the motor nerves out from the center. A touch on the skin starts nerve currents which run along a sensory nerve to the center. Activity in the nerve center starts currents out along the motor

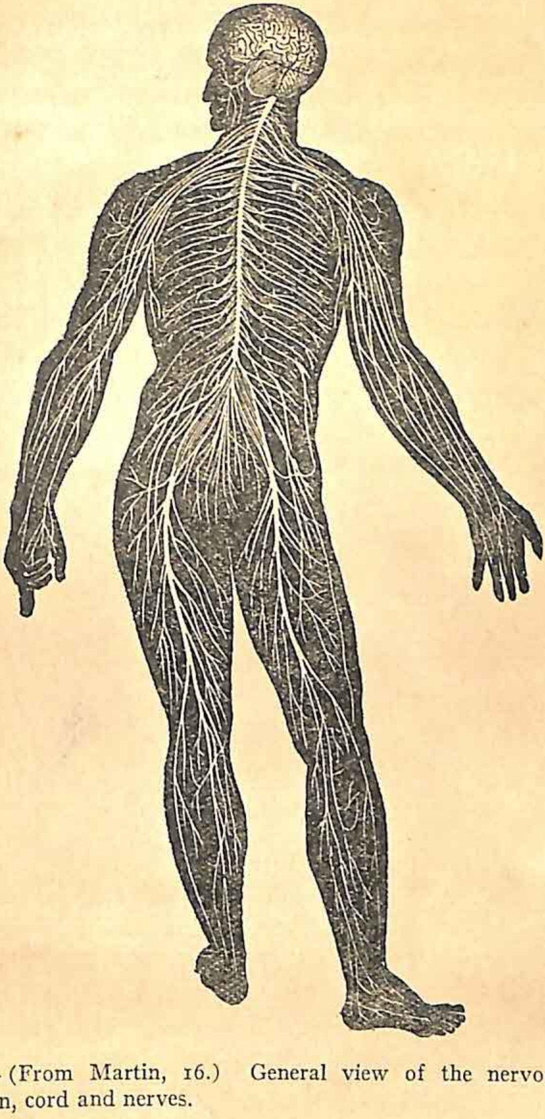


Fig. 28. — (From Martin, 16.) General view of the nervous system, showing brain, cord and nerves.

nerves to the muscles. The advantage of having all the organs tied to a common center is obvious: the organism is able to act as a unit.

Nerve fibers. Even a slender nerve contains many nerve fibers, and the largest nerve in the body, the optic nerve conducting from the eye to the brain, contains up to 400,000 of them. Each nerve fiber is a fine thread, microscopic in thickness but long enough to reach from its sense organ or muscle to the nerve center. The single nerve fiber, like an insulated wire, has a core surrounded by a sheath. The core, called the axon, is a branch of a nerve cell, as we shall soon see. Though so very fine, the axon breaks up into still finer branches where it terminates in a sense organ or muscle, and it is these delicate nerve ends that receive the stimulus in the case of a sensory

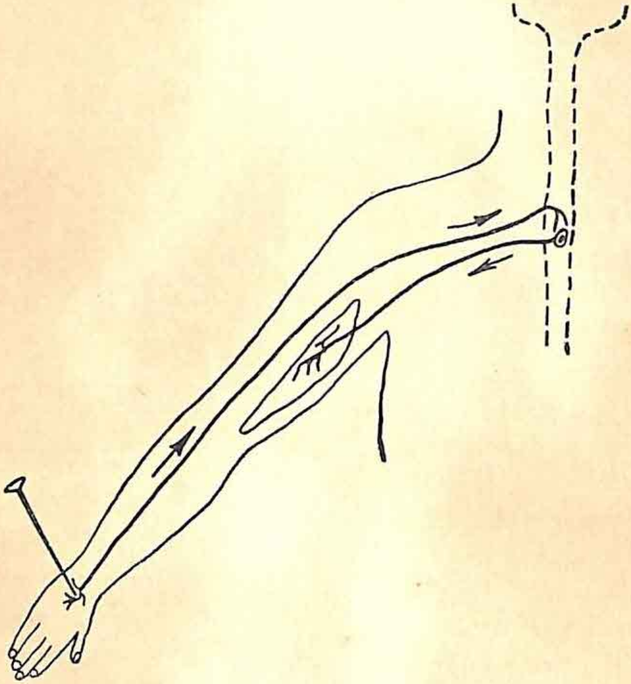


FIG. 29. — The connection from the back of the hand, which is receiving a stimulus, and the arm muscle which makes the response. The nerve center is indicated by the dotted lines.

fiber, and that stimulate a muscle or gland in the case of a motor fiber.

The nerve current. What is it that the nerves conduct? We call it the nerve current, and as far as known it is an electro-chemical wave motion, very weak and consuming very little energy, but capable of arousing a muscle or a nerve center to action. The nerve current travels along the nerve at the fairly respectable speed of something like 100 yards a second.

The waves in different motor nerves are the same in nature and produce different motor effects simply because the nerves lead to different muscles. All nerve currents are fundamentally alike. The nerve fiber is a conductor, and that is all. Stimulated at one end, it passes the stimulation along to the structure with which it is connected at the other end.

"All or none" in nerve fiber activity. A charge of dynamite obeys the all or none law. If it explodes at all it explodes completely. You cannot graduate the force of the explosion by varying the force of the blow with which you set it off. The charge can differ in amount, but whatever amount is present explodes as a unit. Carried over to the nerve fiber, the all or none law states that all the available energy present in the nerve fiber at a given instant is discharged by any stimulus strong enough to arouse the fiber at all. A stimulus may be too weak to arouse the fiber, but if it is strong enough to arouse any response it arouses the maximal response of which the fiber is capable at that particular time.

But this law, which seems to hold good of the single nerve fiber (1) and of the single muscle fiber as well, raises a serious difficulty. How are we to account for the fact that the strength of a sensory or motor response is, very often, graduated according to the strength of the stimulus? A stronger light certainly gives a stronger sensation of light, and a stronger effort gives a stronger muscular contraction.

There are two ways, in spite of the all or none law, in which a stronger stimulus can give a stronger response. First, a stronger stimulus arouses a larger number of nerve fibers. Nerve fibers always act in squads, companies or regiments. Even a pin point on the skin presses the endings of several sensory nerve fibers, and the more strongly it presses the more nerve fibers will be affected. Nerve fibers and their receptive endings differ in sensitivity; a weak stimulus arouses only the most sensitive while a stronger stimulus arouses others as well.

In the second place, a stronger stimulus, though it cannot increase the strength of the single wave in a nerve fiber, can and does arouse more waves per second. The nerve fiber is so quick that its single wave of action is finished in a small fraction of a second. A continued stimulus applied to a nerve fiber arouses a series of response waves, and the stronger the stimulus the quicker the succession of response waves. In a single nerve fiber there may be as few as five waves per second or as many as two hundred, depending on the strength of the stimulus.

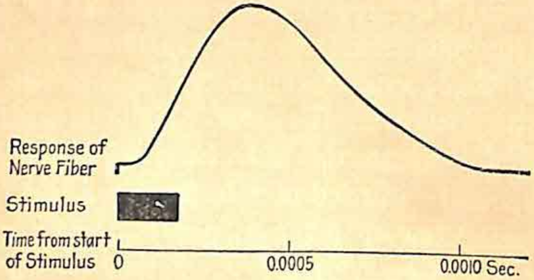


FIG. 30. — The single discharge of a nerve fiber. The discharge, or response, starts a very short time after the beginning of the stimulus, increases in strength for a time and then decreases, coming to an end in about 1/1000 of a second. When the discharge is over the nerve fiber rapidly recovers and can be soon discharged again. The discharge moves as a wave along the nerve fiber.

Putting these two factors together, we see that the strength of a nerve response depends on the number of elementary waves occurring per second, this number depending partly on the number of waves in each fiber and partly on the number of fibers active. This conclusion holds good for sensation and for muscular action alike.

The nervous system compared with a telephone system. If the circulation is a transportation system, carrying materials, the nervous system, carrying messages or stimuli, has some analogy with the telephone system of a town. Both take up little space and consume little fuel. The nerves are like telephone cables in being bundles of insulated conductors, each conductor leading to a separate point outside but all converging to a common center where connections are made. The nerve center, like some telephone centrals, is essentially an automatic switchboard, but the operation of the nerve center is very different from that of any other switchboard. The connections made are multiple rather than single. One incoming call is switched to many outgoing lines, many incoming calls are switched to the same outgoing line, and all the calls at any one time are interconnected. The nerve center is an integrating switchboard.

THE NERVE CENTER

We sometimes speak of many nerve centers, but they are all interconnected and are included within the one big center consisting of the brain and spinal cord. The brain lies in the skull and the cord extends from the base of the brain down through a tube in the vertebral column or backbone. We may think of the brain as consisting of three main parts: the brain stem (an enlarged continuation of the spinal cord) and the two great outgrowths from the brain stem known as the cerebrum and the cerebellum. The brain stem and spinal cord, taken together, are the axis of the whole nervous system. This axis is connected with the sense organs by the sensory nerves and with the muscles and glands by the motor nerves, while it is also connected by great bundles of nerve fibers with the cerebrum and cerebellum.

The nerves of the arms, legs and most of the trunk connect with the cord, while the head and face nerves connect with the brain stem, as do also the nerves of the lungs, heart and stomach. We may speak of the cord as containing the "lower centers" for the limbs and of the brain stem as containing the lower centers for the face, mouth, lungs, etc. The "higher centers" in the cerebrum and cerebellum act upon these lower centers and are acted on by them, and it is only through the intermediary of the lower centers that the higher centers have any contact with the muscles and sense organs or with the environment. The lower centers are masses of *gray matter* lying inside the cord and brain stem, while the higher centers

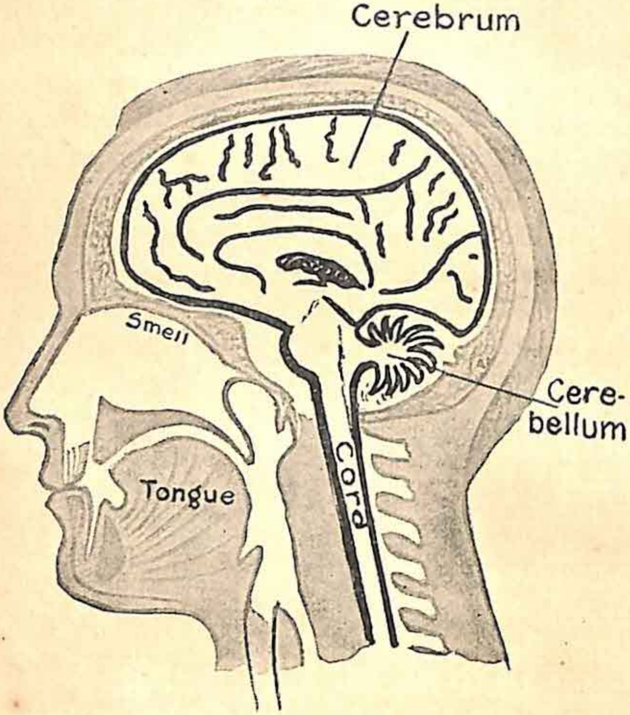


FIG. 31.—Location of the cord, cerebrum and cerebellum. The brain stem continues the cord upward into the skull cavity.

consist of gray matter lying on the surface of the cerebrum and cerebellum and forming the *cortex* (bark) of these structures. The remaining fifty percent (approximately) of the brain and cord is white matter, which consists of nerve fibers linking together all parts of the gray matter, just as the nerves consist of fibers linking the lower centers with the muscles and sense organs.

Like the body, the nervous system is divisible into bilaterally symmetrical halves, and in the cerebrum the right and left halves are called the cerebral hemispheres. It is a curious fact that the nerve fibers connecting the hemispheres with the lower centers cross or "decussate" so that the left hemisphere is connected with the right side of the brain stem and cord and through them with the right side of the body. The right hand and the left hemisphere work together.

THE CELLULAR STRUCTURE OF THE NERVOUS SYSTEM

On microscopic examination, the nerve centers reveal an astonishingly intricate structure consisting of nerve cells and their branches. A *neuron* is a nerve cell including its branches, and the whole nervous system is made up of neurons. Most nerve cells have two kinds of branches, a single *axon* and many *dendrites*. The dendrites are short tree-like branches, while the axon, though very slender, may be inches or feet in length.

The axon, as was said before, is the core of a nerve fiber. The axons in the motor nerves are outgrowths of nerve cells in the cord and brain stem; each motor axon extends from some part of the gray matter of the cord or brain stem out to some muscle (or gland). It receives stimuli from the gray matter and conducts nerve currents out to its muscle where it arouses a small squad of muscle fibers to activity.

The axons of the optic nerve are branches of nerve cells in the retina (the light-sensitive surface inside the eye, see p. 363), and extend into the brain stem. Light entering the eye and falling on the retina excites nerve currents which pass back along the axons of the optic nerve to a lower center in the brain stem and thence to the cerebrum. The olfactory axons are branches of sense cells in the nose. The axons of all the other sensory nerves are branches of nerve cells which lie in little bunches close beside the cord and brain stem, and which, by exception, have no dendrites but bifurcated axons extending

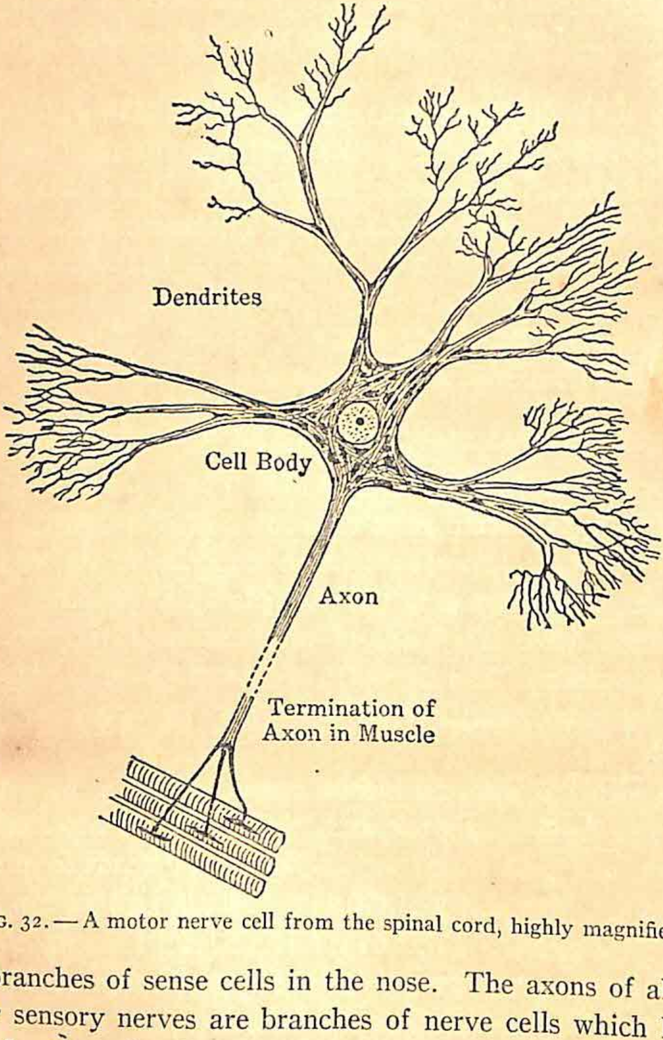


FIG. 32. — A motor nerve cell from the spinal cord, highly magnified.

in one direction outward to the skin or other sense organ and in the other direction inward to the gray matter of the cord or brain stem, thus providing a path from the sense organ to the lower centers.

The dendrites are short and do not extend beyond the gray matter where their cells are located. Gray matter consists of nerve cells and their dendrites, and of the tip ends of axons which have grown into a particular bit of the gray matter and broken up there into fine branches.

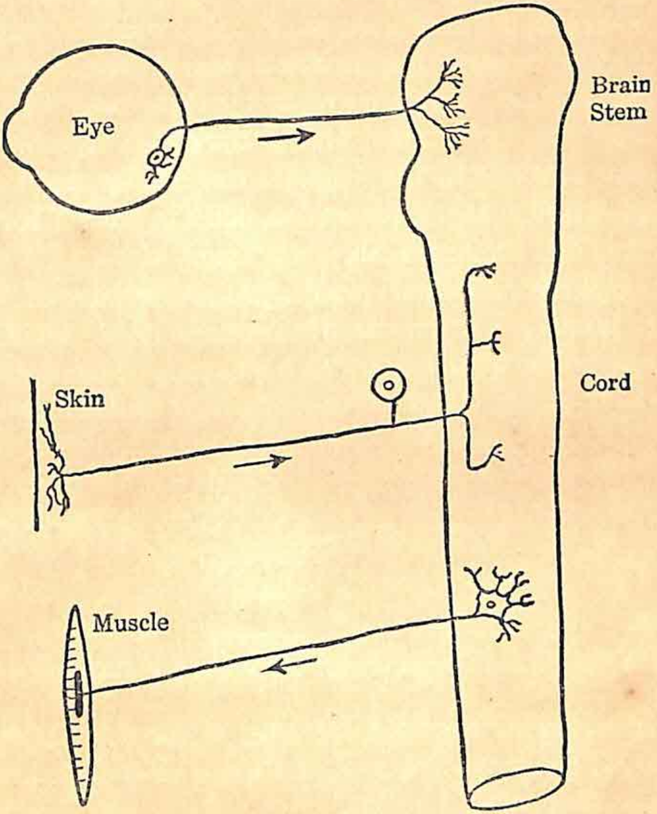


FIG. 33. — Sensory and motor axons, and their nerve cells. The arrows indicate the direction of conduction.

The synapse. It is in the gray matter that neurons are interconnected. Formerly they were supposed to grow together into a continuous network of cytoplasm, through which nerve currents could pass freely in any direction. But this old "nerve net" conception gave way to the "neuron theory," now thoroughly established. The neurons begin their careers in prenatal life as little separate round cells, without branches, and later send out axon and dendrites; and though they establish close contacts with each other by these branches, they never fuse, but each neuron always remains a separate cell. This form of connection, by contact and not by growing together, is called synaptic connection, and the contact between one neuron and another is called a synapse.

For simplicity let us first consider just two neurons and their synaptic connection. The axon of one neuron breaks up into an *end-brush* of fine branches, which interlace with the dendrites of the other neuron. In some cases, however, the end-brush of the first neuron envelops the cell body of the second neuron. In either case the contact is close enough to enable the first neuron to stimulate the second.

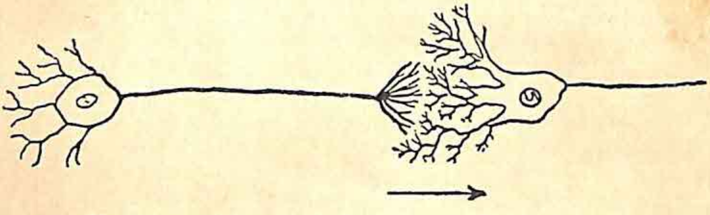


FIG. 34. — The synapse between the two neurons lies just above the arrow.

The dendrite in a synapse is a receiving organ, while the axon end-brush is a stimulator and not a receiver. What happens at the synapse, then, is that the end-brush of one neuron stimulates the dendrites of another neuron. Communication across a synapse is always in one direction, from the end-brush of one neuron to the dendrites (or to the cell body) of another.

Though the contact between neurons at the synapse is close, it is not always and everywhere equally close. Some synapses are visibly closer than others, and it is probable that the resistance of the same synapse varies from time to time, with the condition of the blood, with activity and fatigue and perhaps with repeated exercise or training. It can readily be seen that the synapse is an attractive idea to play with in theorizing as to the physiology of behavior, but one has to admit that the actual happenings in this minute arrangement are only vaguely understood at present.

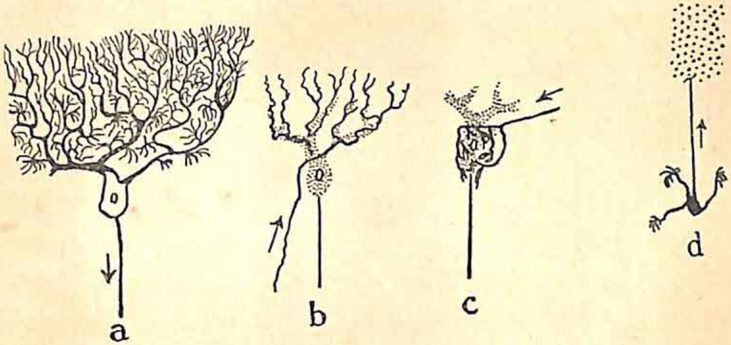


FIG. 35. — Different forms of synapse found in the cerebellum. "a" is one of the large motor cells of the cerebellum (a "Purkinje cell"), with its dendrites above and its axon below; and "b," "c" and "d" show three forms of synapse made by other neurons with this Purkinje cell. In "b," the arrow indicates a "climbing axon," winding about the main limbs of the Purkinje cell. In "c," the arrow points to a "basket" — an end-brush enveloping the cell body; while "d" shows what might be called a "telegraph wire synapse." Imagine "d" superimposed upon "a": the axon of "d" rises among the fine dendrites of "a," and then runs horizontally through them; and there are many, many such axons strung along the dendrites. Thus the Purkinje cell is stimulated at three points: cell body, trunks of the dendrites and twigs of the dendrites.

One misconception that might be created by our simplified diagram should be corrected at once. Single synapses, if they occur, are the exception; multiple synapses are the rule. In any small region of gray matter, several axons can be found terminating in end-brushes, and the cells of that region receive

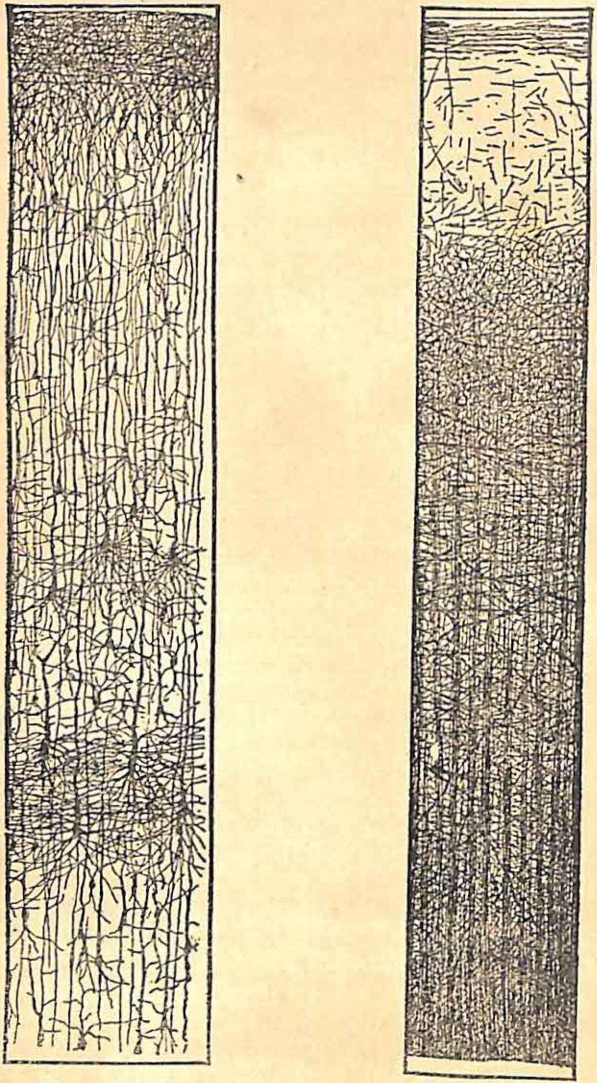


FIG. 36. — (From Cajal.) A small piece of the cortex, magnified to show the complexity of its inner structure. One view shows nerve cells and their dendrites, with only a few axons, while the other shows axons, outgoing and incoming, and some of their fine branches. Imagine one view superimposed upon the other, and you get some idea of the intricate interweaving of axons and dendrites that occurs in the cortex.

stimulation from all these axons, which may have come from quite different parts. The large motor neurons of the cord, which directly control the muscles, are acted on by axons from the local sensory nerves, by axons from various parts of the cord and brain stem, and by axons from the cerebrum — all of which have a share in determining whether or not the motor neuron shall be activated and whether or not the connected muscle fibers shall contract. Any given nerve cell is likely to

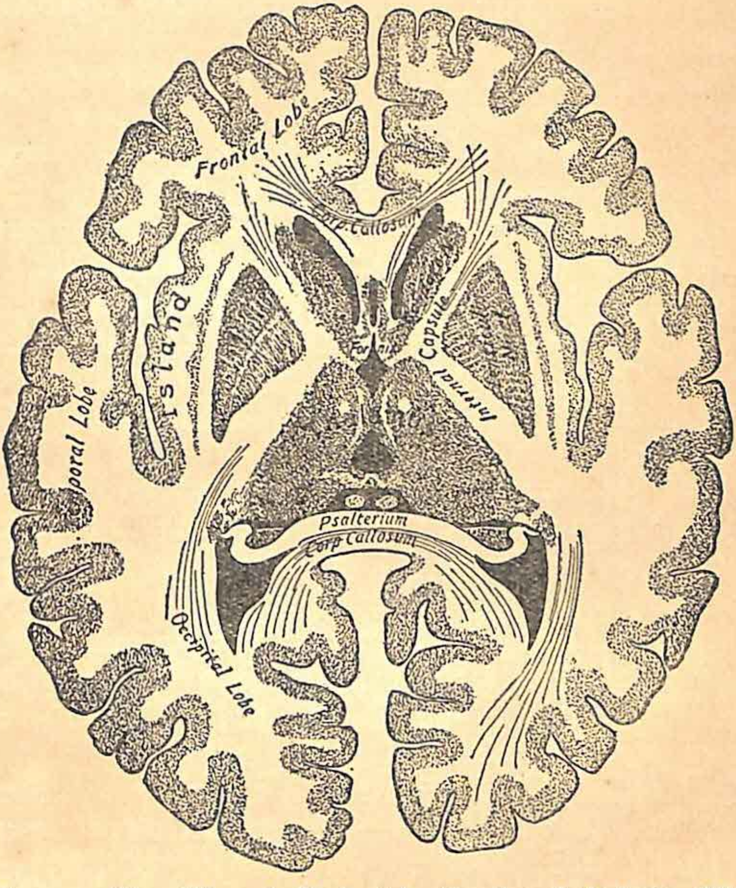


Fig. 37. — (From Edinger.) Horizontal section through the brain. White matter shows white, gray matter gray, and fluid spaces black (13).

be acted on by several other neurons, and also to act upon several others.

The multiplicity and intricacy of synaptic connections in the cerebral cortex are suggested by the accompanying figure (p. 192) which shows a very small portion of the cortex highly magnified.

This view should be considered along with another (p. 195) which gives a faint impression of the extent of the cortex.

The total number of nerve cells in the cerebral cortex is estimated to be about 14,000,000,000. Many of these are small and apparently undeveloped, as if they constituted a reserve stock not yet utilized in the individual's cerebral activity.

Inferences from brain structure to brain function. Starting from the assumption that cortical activity consists of nerve currents moving through nerve cells, axons and dendrites, we can hazard some reasonable conjectures based on the facts of brain structure.

1. With so much intimate contact between adjacent neurons it does not seem possible that they can act separately. The whole arrangement seems to insure that they act in "squads, companies and regiments," as said before.

2. This impression is strengthened when we consider that these numerous interlacing branches are not hard twigs like those of an undergrowth of bushes in a jungle, but delicate soft structures growing or living in a watery medium.

3. Nevertheless the gray matter is not merely a semifluid mass. It has a definite structure which differs indeed from one part of the cortex to another but still shows a good deal of uniformity from part to part and from one individual's brain to another. We cannot hope to understand the activity of the cortex except in terms of its structure.

4. Each bit of cortex shows incoming axons which terminate in that bit and bring in nerve currents; and every bit also shows axons which emerge from the local cells and pass out into the

white matter, carrying nerve currents to other parts of the brain and cord.

5. Besides dividing these axon connections of any bit of cortex into the incoming and the outgoing, we can divide them into "projection" and "association" fibers. The projection fibers lead to or from the lower centers in the brain stem and cord, while the association fibers lead from one part of the cortex to another, a large body of them leading from one hemisphere to the other by way of the "corpus callosum."

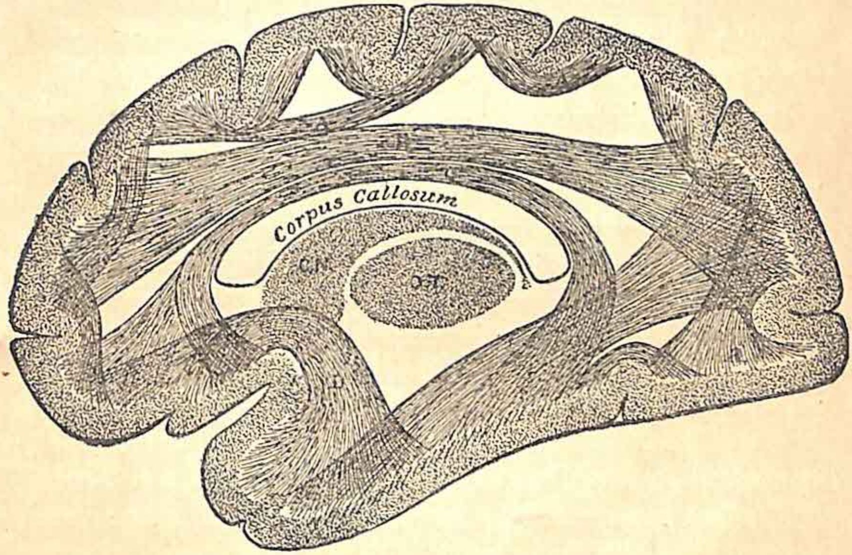


FIG. 38. — (From Starr.) Axons connecting one part of the cortex with another. The brain is seen from the side, as if in section. Note the bundles of comparatively short axons connecting near-by portions of the cortex, and the bundles of longer axons connecting distant parts of the cortex. The "Corpus Callosum" is a great mass of axons extending across from each cerebral hemisphere to the other, and enabling both hemispheres to work together. "O. T." and "C. N." are interior masses of gray matter, which can be seen also in FIG. 37. "O. T." is the thalamus.

6. By its incoming projection fibers, a bit of cortex receives stimuli from the lower centers which themselves receive stimuli from the sense organs. By its outgoing projection fibers, the

cortex stimulates the lower centers which in turn stimulate the muscles and glands.

7. By its incoming association fibers any bit of cortex receives stimuli from other parts of the cortex, while by its outgoing association fibers each bit of cortex passes on stimuli to other parts of the cortex.

8. Thus the internal structure of the brain leads to the conclusion (a) that adjacent neurons act together, (b) that nonadjacent parts of the cortex, interconnected by association fibers, also act together, and (c) that the cerebrum, cerebellum and lower centers, all being interconnected by projection fibers, act together. It should be added that the lower centers themselves are interconnected by nerve fibers. When we try to picture how the nervous system performs its part in any activity of the individual, we have to avoid two opposite errors.

First, the activity of the nervous system at any time cannot be confined to single neurons, to single chains of neurons, or even to any one small local center. The interconnections are so rich that the isolated action of small bits is almost impossible.

Second, it is equally false to say that the cerebrum "acts as a whole." In view of the close connections of cerebrum, cerebellum and lower centers, the statement should at any rate be broadened to read that the nervous system acts as a whole. This more comprehensive statement, however, fails to take into account the elaborate structure of the nervous system, with its definite fiber paths leading from one particular part to another particular part. The connections of the cortex with the lower centers, by way of the projection fibers, differ from one part of the cortex to another; and though the association fibers are not easily disentangled, it is certain that neighboring parts are in general more richly connected than distant parts, that corresponding parts of the two hemispheres are closely tied together, and that in short the association fibers provide specific rather than merely diffuse connections (17).

Another objection to saying that the nervous system acts as a whole is that if we mean "as a whole" literally, we are saying that every single neuron in the whole system is acting at once. Then, according to the all or none law, every neuron is acting full strength. Therefore every action of the nervous system would be the same as every other; the organism could do only one thing and that would amount to a general convulsion. It is certain that the brain performs many different acts, and that no two of them can be performed with exactly the same combination of neurons.

The theory to which we are led is that the brain acts in patterns, and that the patterns must often involve many different parts of the cortex as well as parts of the lower centers.

LOCALIZED AND UNLOCALIZED BRAIN FUNCTIONS

Since different parts of the nervous system differ in structure and have different connections, it is a fair guess that they play different roles in the activity of the organism. This question has been much to the fore ever since about 1800, when Gall propounded his theory of phrenology, a theory which had a vast popular vogue though it never received any scientific support. Gall himself, however, was a scientific anatomist of standing. His method of study was a primitive sort of correlation. When he noticed an individual with a peculiar shape of head, he tried to ascertain his mental peculiarities, so as to tie up different mental and behavior characteristics with different elevations and depressions in the external surface of the skull, from which he believed it possible to infer the degree of development of the underlying brain parts. The intellectual faculties he placed in the front part of the brain, within the forehead, moral characteristics in about the middle (as "veneration" at the very crown), and the animal propensities in the rear, sex desire for example in the cerebellum.

Methods of localization. The evidence for phrenology really amounted to nothing. Gall's analysis of mental abilities and dimensions was rough and ready, he had no way of measuring them, and the surface of the skull does not correspond minutely with the brain inside. Direct study of the brain began however only a little later, by the removal of a part from an animal and noting the resulting changes in behavior and losses of function. Flourens about 1825 showed that loss of the cerebellum disturbed posture, equilibrium and coordination of movement, that injuries to parts of the brain stem disturbed the action of the heart, lungs and other internal organs, and that loss of the cerebrum led to lack of initiative, memory and understanding. But Flourens was more impressed by the generality of disturbance resulting from brain injury, and with regard especially to the cerebrum he concluded that it functioned as a unit. He is regarded as the originator of the doctrine that the cerebrum acts as a whole.

This view of the matter was accepted until about 1860, from which time evidence began to accumulate of different disturbances resulting from injury to different parts of the cerebrum. The human evidence comes from cases of brain tumor, abscess, hemorrhage or wounds, in which the losses of function are noted and the brain examined at autopsy. With the advance of technique and the accumulation of case material, especially during the World War, certain fundamental localizations have become more and more sure and definite. In animals, the method of removal can be applied experimentally, and the method of direct stimulation of small parts of the cortex, as by weak electric currents, can also be applied. Besides, there is the purely anatomical method of tracing fibers and so discovering the connection of part with part.

Motor and sensory areas. In spite of numerous difficulties along the road, these several methods led to the same conclusion. If for convenience each cerebral hemisphere is divided into "lobes," the frontal lobe extending from the front of the brain in the forehead back to the central fissure, the parietal lobe behind that fissure passing over into the occipital lobe at the back of the head, and the temporal lobe lying below the fissure of Sylvius in the region of the temples and rearward, then the sensory and motor areas are located as follows: the motor just forward of the central fissure, the somesthetic (including skin and muscle senses) just behind the central fissure, the auditory in the temporal lobe where it dips into the fissure of Sylvius, and the visual in the occipital lobe. The olfactory area is not visible from the surface but lies in a secluded position covered by the temporal lobe.

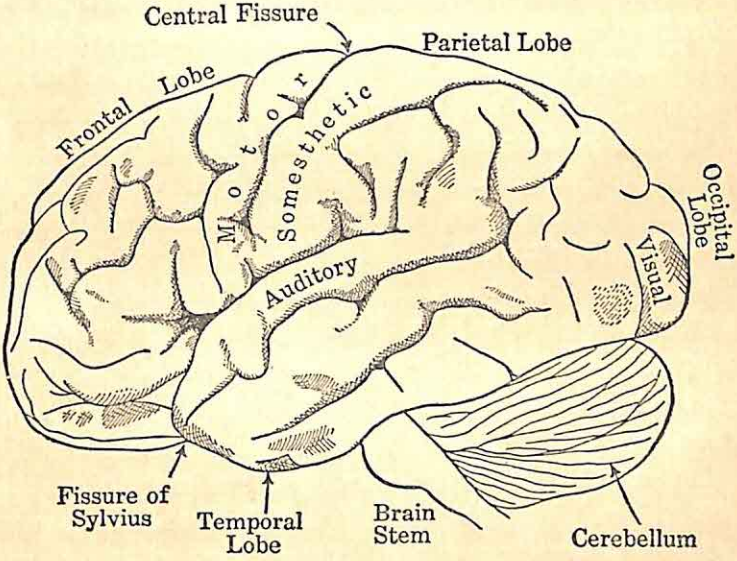


FIG. 39. — Side view of the left hemisphere of the brain, showing the motor and sensory areas (for the olfactory area, see FIG. 41). The visual area proper, or area striata, lies just around the corner from the spot marked "Visual," on the middle surface of the hemisphere, facing the other hemisphere.

The search for higher centers. There was a strong tendency to generalize from the localization of motor and sensory functions and to suppose that the whole cortex could be mapped out into similar limited areas, each serving a different function, probably a "higher mental function." This tendency was strengthened when careful microscopic study was applied to all parts of the cortex, for it was found that the cells and fibers in one area differed somewhat from those in another, and the whole cortex was mapped out into 60–100 anatomical areas, differing in internal structure. Moreover the motor area and the sensory areas were found to have each its own well-marked internal structure; different structure, different function — a perfectly logical point of view. The hope was that the entire cortex could be mapped into well defined functional areas.

Up to about 1900 psychologists had taken no active part in this study of cerebral localization. At that time a new line of experiment was introduced by Franz and later carried further by Lashley. An animal is trained to perform a certain act, then a part of the brain is removed, the animal given time to recover from the general effects of the operation, and then tested to see if he can still perform the learned act or if he can relearn it or can learn another comparable act.

The method seems a good one, but its results are surprising. A performance such as following a path to a goal, or such as manipulating a door-latch, learned before removal of the frontal lobes, is lost as the result of that operation, but can be relearned with further training. Now if the experiment had been terminated when the loss of the performance after operation was established, the conclusion would be that the cortical area necessary for the performance of that act lay in the portion removed. But if so, how could the act be relearned? The conclusion seemed to be that the same act could be learned by different parts of the cortex.

Loss of ability dependent on amount of cortex removed. Another typical result is obtained when a white rat has learned his way through a "maze," a more or less complicated set of paths including some blind alleys. Injury to any part of the cortex (except perhaps the visual, auditory and smell areas) impairs or obliterates this learned performance, which can indeed be relearned. But the relearning process, while rather short and easy if only a small portion of the cortex has been removed, is more difficult if a larger part has been removed. The relation between the amount of cortex removed and the total errors committed during relearning is seen in the following table.

MAZE LEARNING BY RATS AFTER OPERATION (15)

Amount of cortex removed	*Average no. errors committed*
none	33
1–9%	53
10–19%	143
20–29%	293
30–39%	449
40–49%	964
50–	950

Though the loss of maze-learning ability corresponds on the average with the amount of cortex removed, the correlation is not high, running from + .57 to .80 in different experiments. Some individual animals with moderately large amounts removed learned easily, while some with rather small amounts removed learned with much difficulty. Something besides the mere quantity of cortex removed enters as a factor in determining the efficiency of the remaining fraction of the brain.

These results show that a particular learned performance is not controlled by any one small local area. We cannot map the cortex into small, distinct centers, each of which "presides" over a specific mental or motor performance. But as between the theory of "mass action" of the cortex and the theory of "wide-spreading patterns," the experiments do not decide, since the more cortex is removed the more its mere mass effect would be diminished, and the more also any widespread pattern would be disrupted. The same performance, or at least the same external result, can be accomplished by different partial activities of the brain. Just as a dog with a sore paw by hopping on three legs gets to the same place that he would normally reach by running on all four, so, Lashley finds, a rat with an injury to the cerebellum which makes him twist and roll when he tries to run will nevertheless find his way readily through a familiar maze. The same result can be reached by different means, and this seems to be as true of brain patterns as of leg and body movements.

Even as students of the brain had been inclined to generalize too broadly from the definite localization of a few functions, so in recent years the psychologists have tended to make a long jump from the work of their psychological colleagues showing a lack of sharp localization of learned performances, and to cry "Back to Flourens! Brain localization is an exploded theory." Such a conclusion is entirely out of step with the whole range of present-day knowledge, and it will be well to notice the main lines of evidence for one of the sensory areas, the one which has been most fully worked out.

THE VISUAL AREA

Man's eyes, placed side by side and looking forward, get almost (not quite) the same view; both have nearly the same "field of vision." On account of the crossing of the rays of light within the eyeball, light from an object in the right half of the field of view, at the right of the momentary fixation point, falls on the left half of the retina, light from the upper part of the field of view falls on the lower part of the retina; and this is true for both eyes alike. The central part of each retina is specially well developed and provides the most distinct vision; it receives the light from the object "looked at," i.e., from the fixation point and the central part of the field of view. Since we "see single, not double," most of the time, it is clear that the brain must somehow integrate the messages received from the two eyes. Probably, one would guess, the nerve fibers leading to the brain from corresponding parts of the two retinas get together somewhere.

Fiber tracing. The optic nerves, passing back from the eyes, come together and separate again, forming an X which is called the optic chiasm, after the Greek letter Chi. Behind the chiasm they diverge right and left and terminate in the lower visual centers in the brain stem. Masses of nerve fibers emerge from the lower visual center of the right side, pass into the right hemisphere and turn back into the occipital lobe. So much is relatively easy anatomy; but to trace these nerve fibers to their termination very painstaking methods are needed.

One such is the degeneration method. When a nerve fiber is separated from its own nerve cell it degenerates and so can be traced. If the right eye is destroyed (in a monkey or by accident in a man), the entire right optic nerve degenerates back to the chiasm, but from there back to the brain stem the degenerated fibers are divided about equally between the two nerves and so between the two lower visual centers. If the eye injury affects only the right side of the retina (of either retina) the degenerated fibers all go back to the lower visual center of the right side. Thus the nerve fibers from the right halves of both eyes come together in the lower visual center of the right side; and similarly, left to left.

With an injury to the retina, the degenerated fibers end in the lower visual centers; but if one of these lower centers is itself destroyed, degenerated fibers can be traced thence into the occipital lobe, where they all terminate in a limited region of cortex known as the *area striata* or striped area, because of the peculiar stratification of its cells. The area striata is, indeed, one of the best marked of the regions in the anatomical map of the cortex. It lies mostly on the mesial surface of the hemisphere, facing the other hemisphere, and extends from the occipital pole of the cerebrum forward for a couple of inches on this mesial surface. The fiber-tracing method, accordingly, locates the cortical visual area in the area striata. It locates the visual area for the right half of both retinas in the area striata of the right hemisphere, and for the left in the left. The right hemisphere ought to see what the right half of each retina sees, namely, the left half of the field of view.

Varieties of blindness. The results of fiber tracing can be checked by studying the losses of vision resulting from known injuries to different parts of the nerve apparatus.

If the optic nerve is severed between one eye and the chiasm, that eye is of course completely blind, the other not affected.

If the nerve is cut behind the chiasm, on the right side, the left half of the field of view is lost for both eyes alike. This *hemianopsia* ("half blindness") is what we should expect from the results of fiber tracing. The same leftsided hemianopsia occurs when the injury has destroyed the right lower visual center, or the pathway thence to the right area striata, or the right striata itself. The right hemisphere does see the left half of the field of view, etc., as was predicted from the fiber connections. In this way vision is brought into line with body sensation and movement, in which the right hemisphere has to do with the left side of the body.

Finer localization in the area striata. Both the fiber-tracing method and the method of noting losses of function correlated with losses of cortex agree in subdividing the area striata. In man the upper part of the retina is connected with the upper part of the area striata, the lower with the lower; the central part of the retina is connected with the rearmost part of the area, the peripheral part of the retina with the forward part of the area. The projection of both retinas upon the area striata is, then: right to right, and left to left; upper to upper, and lower to lower; central to rear, peripheral to front. The two retinas by their fiber connections are superposed almost point for point in the cortex. It is rather curious that the division of the retina between the two separate areas, one in each hemisphere, produces no discontinuity in the field of view. You see no vertical line or gap dividing the part that you are seeing with the right hemisphere from that part that you see with the left. Presumably the numerous association fibers connecting the two visual areas by way of the corpus callosum provide for the integration of the field (2, 20).

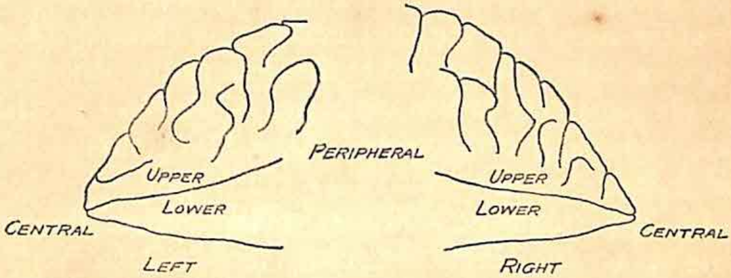


FIG. 40. — Diagrammatic view of rear of cerebrum with the hemispheres separated allowing view of mesial surface. The central part of the retina is projected at the rear pole, the peripheral part further forward, the upper part of the retina above the lower, the left half of each retina upon the left hemisphere, etc.

Effect of stimulating the visual area. Though the results and conclusions stated have now obtained the general acceptance of experts (10), it must not be thought that it was a simple matter to obtain the clean-cut case material necessary. Numerous cases of gun-shot and shrapnel wounds during the World War helped greatly towards what seems now to be a final decision on the main points. There is still another line of evidence which is striking and convincing. When the skull has to be opened up and the occipital lobe exposed to view for the removal of a tumor, a weak electric current can be applied to points on the cortex and the (unanesthetized) subject asked to report his experience. We might hastily assume that he would report pain, on the supposition that the brain must be very "sensitive." But no, stimulation of the visual area ought to give some visual sensation. One leading student of these matters (9) reports the following results in one especially clear case: stimulation at the occipital pole caused the subject to see a bright light straight in front; applied to the upper part of the visual area it caused him to see a flickering something down below, and applied to the lower part of the area it gave the same only in the upper part of the field of view. These localizations correspond to the results obtained by the other methods.

When the electric stimulus was applied outside the area striata but on neighboring parts of the occipital lobe, the subject reported more complex visual appearances: flames, stars, shiny balls, butterflies, various objects and even persons. It would seem then that a large share of the occipital lobe had to do with vision. The area striata, which receives the nerve currents from the retina, undoubtedly passes the stimulation along by association fibers to the neighboring regions, and the latter contribute to the perception and understanding of what is seen. Injuries to the occipital region, if not involving the area striata, are found to produce, not blindness, but inability to recognize objects, or to read, or to distinguish colors, or to find one's way by the sense of sight.

Psychological experiments on the occipital lobe. Experiments on trained rats have shown that the habit of entering a door marked by a white square or any other particular shape is lost when the occipital lobes are removed and that it cannot be relearned, whereas loss of other parts of the cortex does not interfere with this visual recognition of shape. Distinguishing between lights of differing brightness also depends on the occipital lobe, though not quite to the same extent as discrimination of shapes. Light can be distinguished from darkness by the rat, however, even after the occipital lobes have been removed, though if the animal has learned in the intact condition to enter a lighted door and avoid a dark one, he loses the habit when the occipital lobes are removed (14). It would seem from these results that the rat can get along with only his lower visual centers when it is only a question of distinguishing light from dark, but that more precise use of visual data requires the presence of some amount of occipital cortex. Man is more dependent on his cortex than the rat, and is absolutely blind if the occipital lobe is lost from both hemispheres. One characteristic of the higher mammals, and especially of man, is the great size of the cerebrum in comparison with the brain stem. Functions that are performed by the brain stem in lower forms have been shifted to the cerebrum in man.

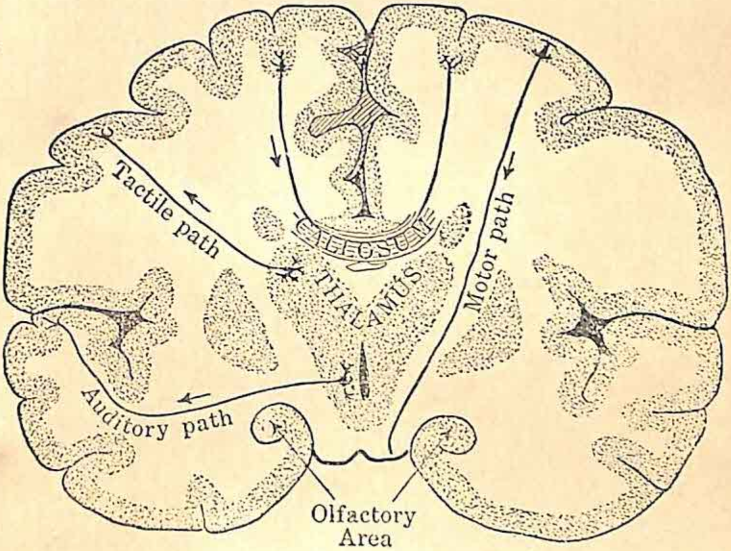


FIG. 41. — Vertical cross-section through the brain, showing the cortex on the outside, the thalamus and other interior masses of gray matter, some of the paths to and from the cortex, and the callosum or bridge of axons connecting the two cerebral hemispheres. The "Motor path" is the pyramidal tract, only the beginning of which is shown here, its further course being indicated in FIG. 44.

Other sensory areas of the cortex. Similar work has been done on the other senses and similar results obtained. Each sense has a lower center in or adjacent to that part of the brain stem known as the *thalamus*. Incoming fibers from the sense organs lead to this region, and from it emerge fibers which pass to the several sensory areas of the cortex. Destruction of the auditory area in both hemispheres makes the individual deaf, and destruction of any part of the somesthetic areas abolishes sensation in some part of the body.

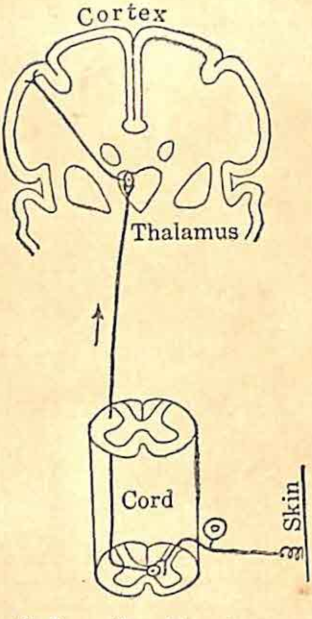
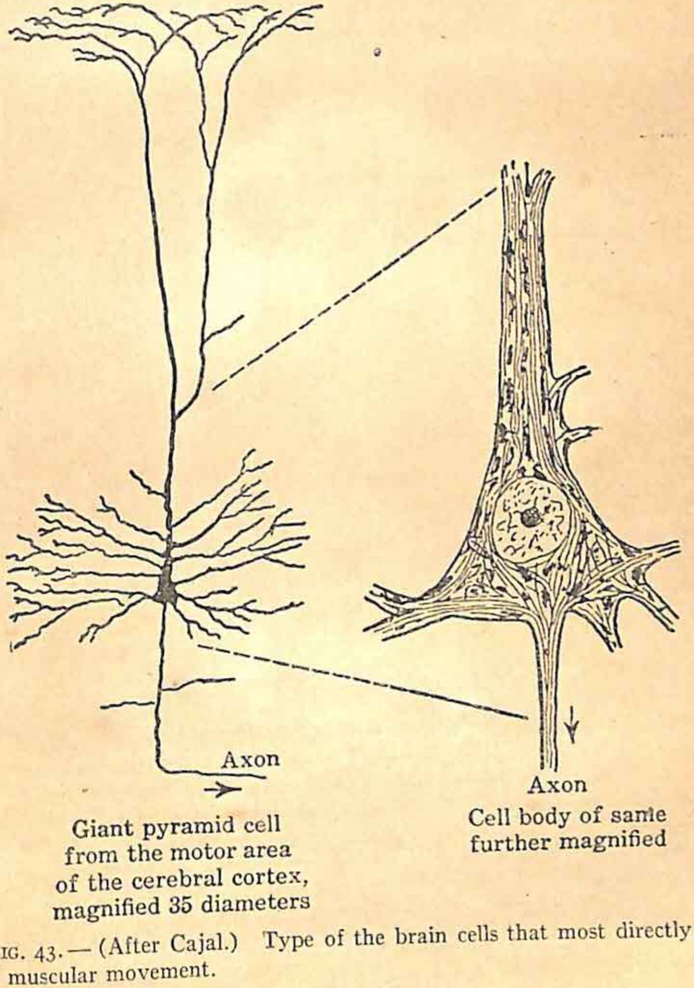


FIG. 42. — Sensory path from the skin of any portion of the trunk or limbs. The path consists of three neurons, the cell body of the first lying just outside the spinal cord, that of the second lying in the cord, and that of the third lying in the thalamus. The last part of this path is the "Tactile path," shown in FIG. 41.

THE MOTOR AREA

The strip of cortex adjoining the central fissure on its forward side contains the "giant pyramids," the largest of nerve cells, and the axons of these giant cells extend down through the brain stem and cord, terminating at various levels and connecting with the motor nerve cells whose axons in turn directly



Giant pyramid cell from the motor area of the cerebral cortex, magnified 35 diameters

Cell body of same further magnified

FIG. 43. — (After Cajal.) Type of the brain cells that most directly control muscular movement.

reach the muscles. Electrical stimulation of this narrow strip of cortex gives muscular movements which differ according to the part of the strip stimulated. Stimulation at the top of the brain near the middle line gives leg movements; further down, arm movements; still further down, head and face movements. Many different movements can be elicited, and they are all coordinated movements rather than contractions of isolated muscles. Removal of small portions of this strip of cortex produces temporary or more permanent paralysis of the corresponding movements. From its fiber connections, and from the results of removal and stimulation, this narrow giant-pyramid strip has been called the motor area.

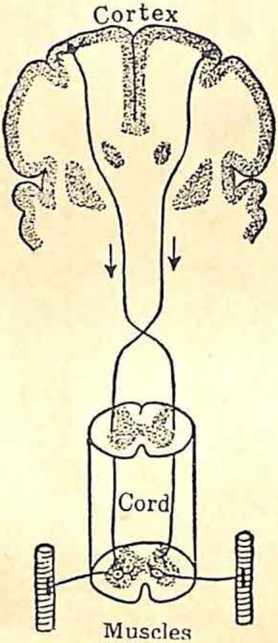


FIG. 44. — The nerve path by which the motor area of the cortex influences the muscles. The upper part of this path, consisting of axons issuing from the giant pyramids of the motor area and extending down into the spinal cord, is the pyramidal tract. The lower part of the path consists of axons issuing from the motor cells of the cord and extending out to the muscles. The top of the figure represents a vertical cross-section of the brain, such as is given, on a larger scale, in FIG. 41.

The complete motor area, however, includes also a parallel strip called the premotor area, lying just forward of the giant-pyramid strip. The fiber connections from the premotor area downward to the muscles are less direct than those of the motor area. Stimulation of the premotor area gives more complex movements than are obtained from the motor area, and at some points coordinated movements of *both arms* or legs.

Removal of the giant-pyramid area produces temporary paralysis in the part of the body corresponding to the part removed, and after this paralysis has passed off there remains a lack of speed, smoothness and precision in the movements of the affected limb, a disinclination to use that limb and an inability to use it in really difficult motor performances. Removal of the premotor area disturbs not so much the efficiency of single movements as the pattern of combinations of movement. When both the motor and the premotor areas are removed from both hemispheres the animal is completely paralyzed and this paralysis is permanent (3, 4, 11, 19).

Even the motor and premotor centers, taken together, do not however cover all the motor functions of the cortex. Eye and head movements can be obtained from the occipital lobe (as if in response to a seen object), from the temporal lobe (as if in response to a sound) and from the frontal lobe (as if in spying out one's way). Outgoing projection fibers, probably motor in function, lead from all parts of the cortex to the brain stem. Many of them link the cerebrum, through the brain stem, with the *cerebellum*. This large organ receives sensory fibers also, and sends out fibers which have a motor effect. The cerebellum has much to do with maintaining posture, equilibrium and muscular steadiness. The cerebrum and cerebellum work as a team, the cerebrum taking the initiative, taking account of the environmental situation and providing the trained skill, as for example in kicking a football at the right time and in the right direction, while the cerebellum insures such an adjustment of posture as enables the player to kick and still maintain his equilibrium.

THE ASSOCIATION AREAS OR INTEGRATING AREAS

With the sensory and motor areas identified, there still remains a large fraction of the cortex unaccounted for, especially in the human brain. There is one large area lying in the parietal, temporal and occipital lobes, intervening between the several sensory areas; and there is another in the frontal lobe forward of the motor and premotor areas. These are called association areas, on the theory that they serve to combine or integrate the activities of the sensory and motor areas. Their function is thus supposed to be synthetic. The evidence regarding them comes mostly from cases of brain injury in man. The functional losses resulting from such injuries are classed under several heads (17).

Aphasia is a loss or disturbance of speech, and occurs in several different forms. Through brain injury an individual may become unable to hear speech with any understanding, or unable to find the right words to express his meaning, though he may speak fluently; as one old gentleman mystified his friends by asserting that he "must go and have his umbrella washed," till it was discovered that he wanted his hair cut. The brain injury in such cases as the above is likely to be in the neighborhood of the auditory area. In other cases the great difficulty is to get the words out, some subjects being able to speak only one or two words of very frequent usage (as "yes" and "no" and swear words), while others can pronounce separate words but cannot put them together into sentences. In this class of cases the injury is apt to be in the premotor area, a part of which has long been known as the motor speech center, though of late years it has been regarded with some scepticism.

Apraxia, or loss of ability to "do," is akin to aphasia. A test consists in giving the individual a box of matches and a cigar; he may be unable to make the right combinations, though perfectly capable of making all the necessary single movements. The injury varies in location, but is usually not far from the motor area, either in front or behind.

Agnosia, or loss of ability to "know" or perceive. Visual agnosia was alluded to before in connection with the occipital lobes; it consists in inability to recognize objects, words, shapes and colors. In auditory agnosia, sounds cannot be recognized, or music cannot be followed and appreciated as before. The injury here is in the neighborhood of the auditory area. When the injury is close behind the somesthetic area, the subject cannot recognize objects placed in his hands, judge weights by lifting them, etc. In an agnosia the subject still sees, hears or feels, but he cannot utilize the sensory data as signs of definite objective facts.

The cortex adjacent to the area for each sense seems, then, to be necessary for grasping the facts presented to that sense, and the region near the motor area seems concerned with skilled and effective movement. The closer a region is to a sensory center, the more closely its function seems to be tied to that particular sense; and the further removed it is from the sensory or motor areas, the more synthetic its function may probably be. The frontal lobe, so large in man, would then be a sort of supermotor area, concerned in planned series of actions; and there is some evidence for this view, since the behavior after a frontal lobe injury is apt to be characterized by impulsiveness, irresponsibility and lack of plan.

THE REFLEX ARC

In the intact organism the lower and higher centers work intimately together; but the lower can operate to a certain extent even when separated from the higher. Transection of the spinal cord, separating the lower part completely from the brain, occurs by accident or in an animal experiment. A pinch applied to one hind paw still gives a quick response called the "flexion reflex" by which that paw is pulled up while the opposite leg is thrust downward. This reflex ceases if the lower part of the cord is destroyed or its nerves cut.

A reflex is a prompt muscular or glandular response to a sensory stimulus, an involuntary and unlearned response. A local reflex is one obtainable from a fraction of the whole organism. The machinery that carries out a reflex includes a sensory nerve entering the gray matter of the cord or brain stem, and a motor nerve issuing from this gray matter and leading to the responding muscles. A minimum diagram of this reflex mechanism shows a sensory axon leading into the gray matter of a lower center and forming synaptic connection there with a motor neuron whose axon extends out to the muscle. This combination of a sensory and a motor neuron makes up a two-neuron "reflex arc."

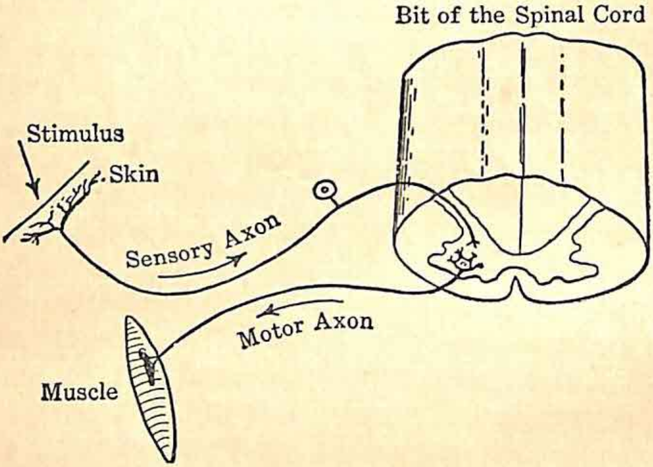


FIG. 45. — A two-neuron reflex arc.

A three-neuron arc is the minimum diagram for breathing, which can go on in the absence of the brain, provided the lower part of the brain stem and the upper part of the cord, with their nerves, remain intact.

Such local reflexes were once regarded as the fundamentals of motor activity, and the organism's behavior was supposed to consist in combinations of reflexes. The reflex arc was accordingly regarded as picturing the elementary fact in nerve machinery. But there are several objections to this theory.

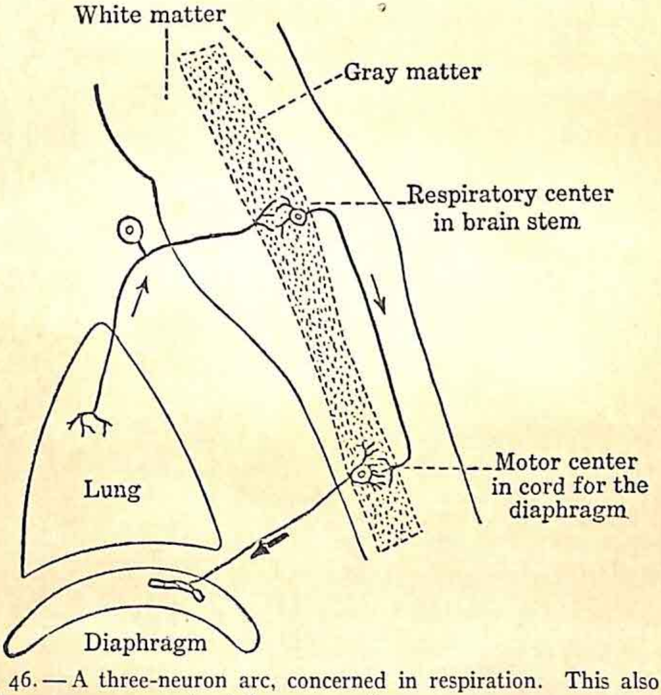

White matter
Gray matter
Respiratory center in brain stem
Motor center in cord for the diaphragm
Lung
Diaphragm

FIG. 46. — A three-neuron arc, concerned in respiration. This also illustrates how one nerve center influences another.

1. **Multiple nerve paths.** Single sensory neurons, and especially single motor neurons, do not act separately. Neurons act in squads, etc., as has been said. (See pages 184, 194.)

2. **Converging paths.** The gray matter in any lower or higher center receives incoming axons from several or many different parts of the nervous system, and is thus subjected to a combination of influences rather than to a single stimulus. The respiratory center in the brain stem, for example, receives not only sensory nerve currents from the lungs but currents from

many or all other sensory nerves as well, so that breathing is instantly modified by a painful stimulus, by a sudden loud noise, or by a dash of cold water on the skin. The respiratory center also receives nerve fibers from the cerebrum, as we can judge from the fact that the breath can be hastened or slowed voluntarily, and from the modification of breathing that occurs in speaking. Further, the rate and depth of breathing are affected by the amount of carbon dioxide in the blood circulating through the respiratory center. So the simple three-neuron arc is very far from an adequate picture of the mechanism of breathing.

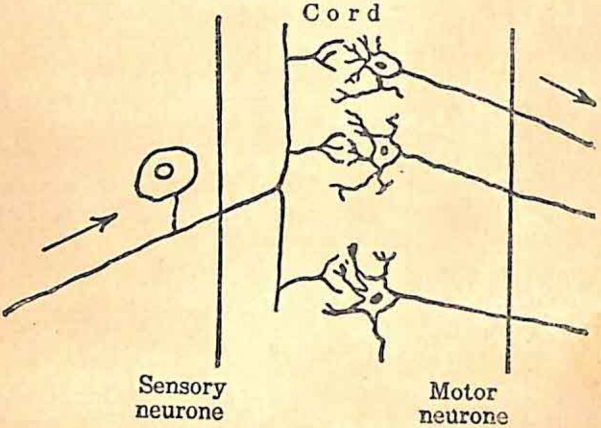


FIG. 47. — Coordination brought about by the branching of a sensory axon.

3. **Branching paths.** An adequate picture must show not only converging axons, but also branching axons by which any single neuron can exert its influence upon several other neurons. Thus the nerve currents coming from a single part can be distributed to many parts. The numerous muscle fibers in a single muscle are thus made to act together, and several muscles can be aroused at the same time in a coordinated movement.

4. **Facilitation and inhibition.** When two axons from different regions come together into a bit of the gray matter, they

facilitate or assist each other's stimulating effect, or they neutralize or inhibit each other's effect. Exactly how inhibition works in the gray matter is not yet known, but one instance of it is afforded by the momentary cessation of breathing when cold is suddenly applied to the skin.

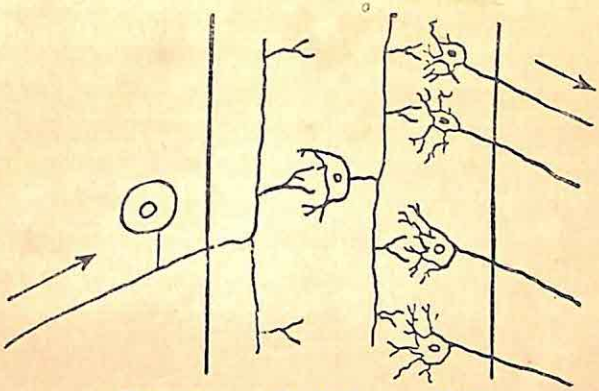


FIG. 48. — Coordination brought about by the branching of the axon of a "central" neuron.

5. Continued activity. The reflex arc diagram may suggest a nerve center resting quietly until a particular stimulus arrives — whereas the typical condition of the nerve center is one of activity. The activity already going on in a nerve center is modified, facilitated or inhibited, by the incoming nerve currents. We have to think of the nervous system as constantly active, at least during waking hours, as constantly subjected to many varied stimuli and as constantly shifting in its pattern of activity.

6. Larger movements not compounds of the local reflexes. Since reflexes are present in the young child, they have been represented as the primary elements from which all motor activity arises by combining them into numerous complex acts. One objection to this conception comes from studying the behavior of embryos and is to the effect that general movements may antedate local reflexes. (See page 168.) The general body movements, then, are not combinations of small local reflexes. The smaller movements appear to differentiate out of the larger (5).

The newborn human infant's motor activity contains a good number of reflexes, but for the most part does not consist of well-marked reflexes. Observers who have sought to describe it have been baffled by its multifariousness and "fluidity." When the baby cries he is apt to stiffen or kick, his movements not being confined to one small region at a time, by any means; and the same is true of his movements while in a happy mood. It is clear, then, that the skillful learned movements which he develops a little later are not built up out of the definite reflexes but are differentiated out of his miscellaneous motor activity (21).

MATURATION AND EXERCISE IN THE DEVELOPMENT OF THE NERVOUS SYSTEM

There is abundant evidence of maturation. The first rudiment of the nervous system appears when the embryo is about two weeks old. A longitudinal groove appears in the outer layer of cells in the region that is to become the back, and this groove shortly closes over and forms a tube. These developments so far are a response of one part of the embryo to the influence of adjoining parts, and not to external stimulation. The metabolic activity is greatest at the head end of the embryo, and that end of the neural tube develops most rapidly and most elaborately, so that at the early age of four weeks of embryonic life the main parts of the brain are distinguishable.

In these early stages, the cells composing the rudimentary brain and cord are not neurons, but as the cells multiply, they come to have the character of nerve cells, and send out first their axons and later their dendrites. The motor neurons and nerves develop earlier than the sensory. The brain develops early, and the cerebral cortex shows growing nerve cells, with axons and dendrites, long before this portion of the nervous system can be participating in the simple activities of the fetus. It is clear from these facts that the general form, structure and characteristics of the brain develop by maturation.

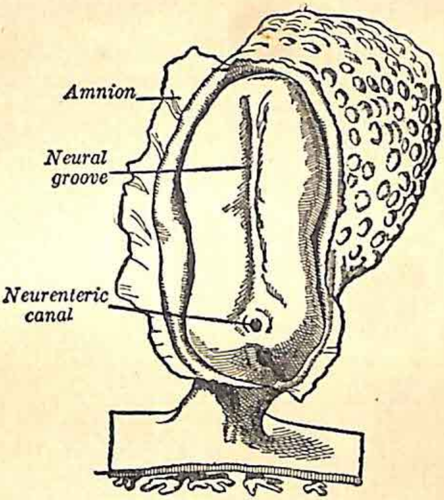


FIG. 49. — Dorsal view of a two-weeks' human embryo. (Von Spee, from Ladd and Woodworth, 13.) The future head end lies above in the figure, which is magnified 20 diameters.

Evidence for growth of the nervous system through its activity is less clear, but there is evidence. Though no new neurons are formed after birth, growth of the nerve cell and of its branches continues rapidly in early childhood and more slowly on into adult life. This growth need not be entirely due to activity but activity is probably one stimulating factor. In the area striata, which certainly is active enough after birth, the nerve cells increase in size up to the age of eight years and apparently to some extent even later (8). In individuals who become blind at an early age, this development of the area striata is much less marked (6, 12). An experiment was tried on white rats to see if great muscular activity would increase the total size of their brains. They were taken at the age of one month, and divided into an experimental and a control group, the experimental group being provided with cages having rotating wheels in which they ran a good share of the time, while the control group was kept in ordinary cages and were much less active. Their brains were weighed at the age of seven or eight months, and it was found that the brain of the exercised animals

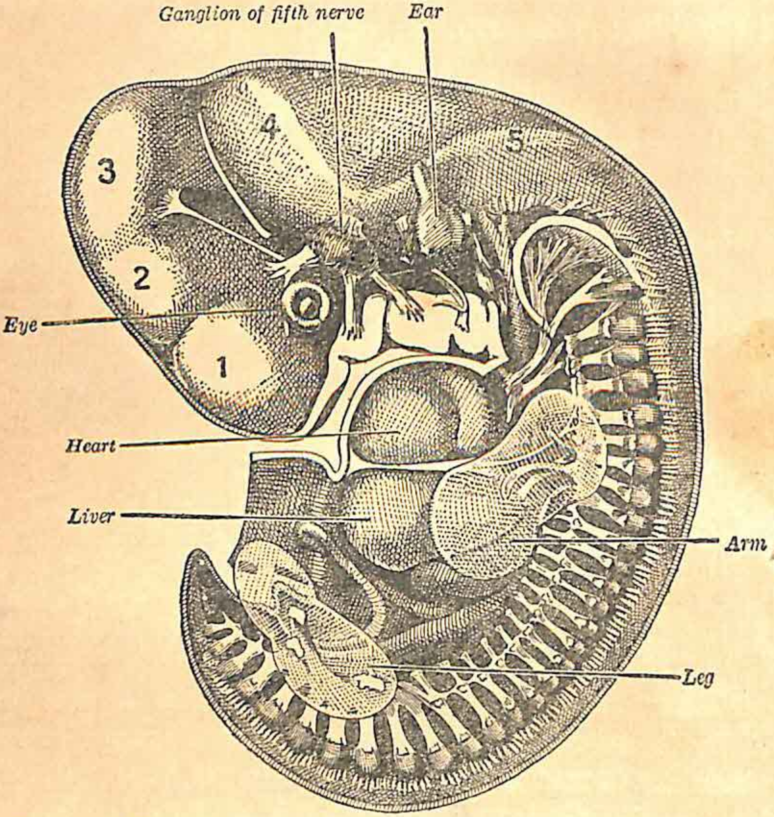


FIG. 50. — Human embryo of about four weeks. (Streeter, from Ladd and Woodworth, 13.) 1, 2, 3, 4, 5, rudiments of the main parts of the brain. The spinal cord shows in gray and is continuous with 5, the rear of the brain stem. The nerves are white in the figure. The rudiments of the arms and legs show as transparent buds. Magnified about 10 diameters.

was heavier in most cases than that of the controls, 2.5% heavier on the average (7).

If function depends on structure, and if changes in activity resulting from learning and training mean that there has been some change in structure, then it is certain that the process of learning must produce structural changes in the brain, even though they need be only the microscopic growth of dendrites and end-brushes in the gray matter of the higher and lower centers.

REFERENCES

1. Adrian, E. D. *The basis of sensation.* 1928. pp. 25–30.

2. Brouwer, B. *Anatomical, phylogenetical and clinical studies on the central nervous system.* 1927.

3. Bucy, P. C. "Representation of ipsilateral extremities on cerebral cortex." *Science,* 1933, 78, 418.

4. Buytendijk, F. J. J. "Le cerveau et l'intelligence." *J. de Psychol.,* 1931, 28, 345–371.

5. Coghill, G. E. *Anatomy and the problem of behavior.* 1929.

6. Donaldson, H. H. "Anatomical observations on the brain and several sense-organs of the blind deaf-mute, Laura Dewey Bridgman." *Amer. J. Psychol.,* 1890, 3, 293–342; 1891, 4, 248–294.

7. Donaldson, H. H. "On the influence of exercise on the weight of the central nervous system of the albino rat." *J. Comp. Neur.,* 1911, 21, 129–137.

8. Filimonoff, I. N. "Zur embryonalen und post-embryonalen Entwicklung der Grosshirnrinde des Menschen." *J. Psychol. u. Neur.,* 1929, 39, 323–389.

9. Foerster, O. "Beiträge zur Pathophysiologie der Sehbahn und der Sehsphäre." *J. Psychol. u. Neur.,* 1929, 39, 463–485.

10. Holmes, G. "A contribution to the cortical representation of vision." *Brain,* 1931, 54, 430–459.

11. Jacobsen, C. F., & Fulton, J. F. "The influence of extirpation of the motor and premotor areas of the cortex upon the retention and execution of acquired skilled movements in primates." *Psychol. Bull.,* 1933, 30, 559–560.

12. Kappers, C. U. A. *The evolution of the nervous system in invertebrates, vertebrates and man.* 1929. esp. p. 144.

13. Ladd, G. T., & Woodworth, R. S. *Physiological psychology.* 1911.

14. Lashley, K. S. "Cerebral control versus reflexology: a reply to Professor Hunter." *J. Gen. Psychol.,* 1931, 5, 3–20.

15. Lashley, K. S., & Wiley, L. E. "Mass action in relation to the number of elements in the problem to be learned." *J. Comp. Neur.,* 1933, 57, 1–55.

16. Martin, H. N. *Human body.* rev. by E. G. Martin, 1917.

17. Milch, E. C. "Sensory cortical area: an experimental anatomic investigation." *Arch. Neur. Psychiat.,* 1932, 28, 871–882.

18. Piéron, H. *Thought and the brain.* tr. by C. K. Ogden. 1927.

19. Pike, F. H., & Chappell, M. N. "On the recovery following lesions in the cerebral cortex." *Science,* 1930, 71, 76.

20. Poljak, S. "A contribution to the cerebral representation of the retina." *J. Comp. Neur.,* 1933, 57, 541–617.

21. Pratt, K. C. "The neonate." *Handbk. Child Psychol.,* 1933, 2nd ed., 163–208, esp. p. 199.

CHAPTER X

LEARNING

We need no elaborate survey of human life to convince us that the work of psychology must consist very largely in the investigation of learning. If the individual were incapable of learning, his behavior at any time would "start from scratch" without any momentum gained from previous activity, and his experience at any time would be all new, with no memory and no perspective. There would be no "getting acquainted with" a person or thing, no "getting used to" a situation, however often it might recur, and no possibility of acquiring knowledge or skill through observation, study or practice. In view of all the learning that obviously occurs from the cradle to the grave, psychology wishes to discover *what* essentially is learned, *when* or under what conditions it is learned, *how* or by what process it is learned, and what difference it makes to the individual.

Learned and unlearned activities. Breathing as it occurs in the infant at birth cannot have been learned; the necessary structures must have been prepared by maturation. The child does learn to *modify* his breathing in various ways, as in holding his breath at will, or in blowing out a match. These learned modifications of breathing are based upon the original unlearned act. Any act, though provided in its primitive state by pure maturation, is almost sure to be strengthened and regularized by exercise, as we saw in the case of the young chick's pecking; and just so far as it has been changed by exercise it has become a learned act. There can be few wholly unlearned acts in an adult. And there can be no wholly learned acts, for the structures that perform any act are laid down in the rough by maturation.

Definition. A learned activity shows the effects of previous activity. It is performed by structures which have been developed, in part, by previous activity. Learning must accordingly be the process of developing structure through activity. Or, learning is activity which develops structure.

This definition seems correct but not very useful as a pointer. We do not insist on seeing a change in the individual's brain structure before admitting that he has learned something. All we can usually observe is the effect of earlier on later activity. We postulate development of structure because yesterday's activity cannot *directly* have any effect today. It had its effect yesterday, and the only bridge between yesterday and today is afforded by the enduring structure of the individual. We could leave out the *word* structure and define learning as any activity of the individual which develops him and so affects his subsequent activity.

Learning, as we shall see, is no one particular kind of activity. We learn a tune by listening to it, we learn the plot of a story by reading the story, we learn to skate by skating. Any activity can be called learning in so far as it develops the individual and makes his later behavior and experience different from what they would otherwise be.

Learning a fruitful field for experiment. Systematic experimentation on learning began about 1880 with studies of human memory. A few years later work started on the acquisition of motor skill, followed at the turn of the century by the pioneer experiments on animal learning. These leads have all proved excellent and are still being followed up energetically.

The logical framework of a learning experiment is fairly simple: the learning process is sandwiched in between an initial and a final test of some performance, and the final test is compared with the initial test to see what change in the performance has been produced by the interpolated learning. For example, to discover how much a class learns from listening to a certain lecture, the class should be examined both before and after the lecture and the difference in test scores noted. Sometimes test and learning are alternated time after time so as to reveal the cumulative effects of learning.

The value of animal experiments in the study of learning. Among many kinds of animals that have been used, the favorites are apes and monkeys because of their closeness to the human, and the white rat, because of his cheapness and convenience and because, being bred in laboratories for scientific purposes, he is a standardized animal of known heredity, known age and known feeding and other treatment up to the time of the learning experiment. But you may ask why anyone should be particularly interested in the psychology of the rat. The answer is very important, though it may not be at once understood and appreciated. Psychology is a *general* science rather than a specific study of one form of animal even though that animal is so near and dear to us as the human species. Psychology seeks to unravel the learning process not as a specifically human process — which it is not — but as a process common to many if not all animals. The simpler processes in the rat are instructive just because of their comparative simplicity. The architecture of a cottage helps in understanding the architecture of a cathedral.

If animals are to be made useful to psychology, care must be taken to observe them as objectively as possible, without reading human characteristics into their behavior. That is, we must be on our guard against anthropomorphism. This principle was laid down by one of the founders of animal psychology and is named, in his honor, *Lloyd Morgan's canon.* As he put it, " In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty, if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale" (15). When, for example, a dog learns to open a gate by raising the latch, we are not justified in assuming that he reasoned out the solution, if his behavior, followed in detail, can be described as trying one thing after another until something works. By reading our own mental processes into the animal, we should probably misjudge the animal and certainly miss our opportunity of securing a clear view of the more primitive types of behavior, on which the higher and more complex types are based.

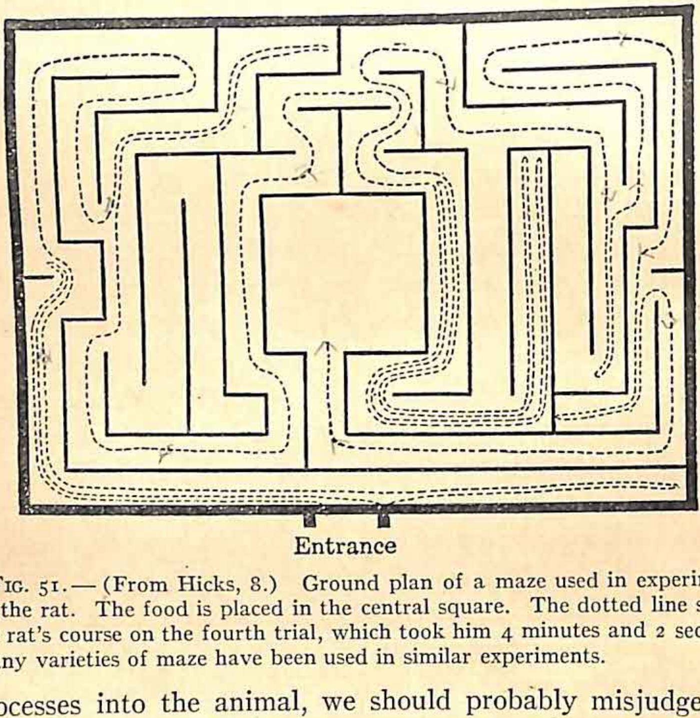


FIG. 51.— (From Hicks, 8.) Ground plan of a maze used in experiments on the rat. The food is placed in the central square. The dotted line shows the rat's course on the fourth trial, which took him 4 minutes and 2 seconds. Many varieties of maze have been used in similar experiments.

PLACE LEARNING

Locations and paths are relatively easy to learn and are learned by animals much lower in the scale than man.

The white rat in the maze provides a fundamental experiment in this type of learning. Placed in a complicated enclosure, a rat begins to explore. He goes back and forth sniffing everywhere, enters all the passages, and in course of these wanderings finds food in a certain part of the maze. Replaced at the starting point, he proceeds with more appearance of haste and with less dallying in the blind alleys. In successive trials he is apt to go less and less deeply into a given blind alley, till finally he passes it without even turning his head. In time he eliminates all the blind alleys and runs rapidly through the maze from the entrance to the food box.

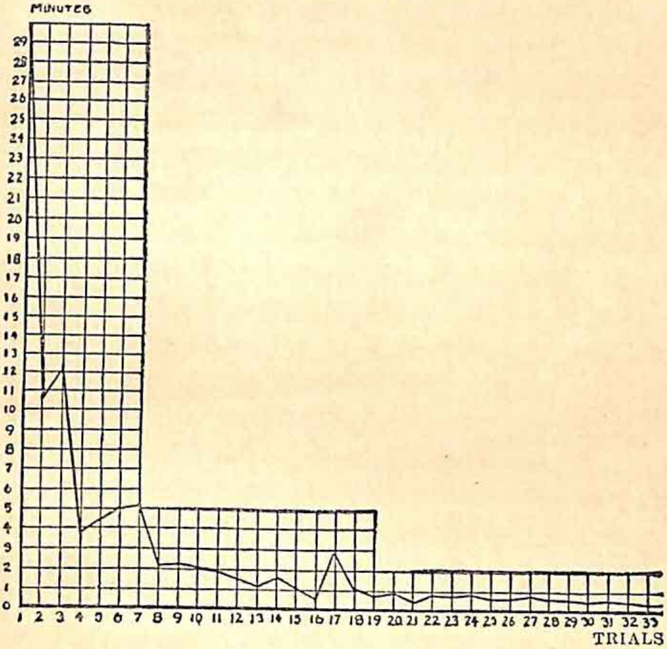


FIG. 52. — (From Watson, 29.) Learning curve for the rat in a maze — a composite or average curve, derived from the records of four animals. The height of the "curve" (broken line) above the base line at any trial shows the number of minutes taken in that trial for passing through the maze from start to food box. The gradual, though irregular, decrease in running time pictures the progress of the animals towards their final rapid and regular performance.

When we compare the rat's early wandering with his final smooth run through the maze, and ask just what the animal has learned, we may be inclined to adopt the *chain reflex* theory.

The animal according to this theory learns a fixed series of movements, each of which as it occurs furnishes the stimulus calling out the next movement in the chain. The stimulus furnished by a movement of the animal might be a visual or olfactory stimulus received from the place now reached, or it might be an internal kinesthetic or muscle-sense stimulus (p. 395) produced by the animal's movements and posture. In the case of the white rat, one would expect the olfactory cues to be especially important; and experimenters have to take precautions to prevent the rat from following the scent of the food or his own previous trail through the maze. But a remarkable fact was soon discovered: after a rat has learned a given maze, he continues to run it almost or quite perfectly even when deprived of smell, or of vision, or of hearing, or of the sense of touch from his foot pads and vibrissae. It seemed then that the muscle sense must be furnishing the stimuli for the successive movements so that the chain reflex in maze running, once well learned, was conceived as a wholly internal automatism.

A path rather than a chain of movements is learned. The chain reflex theory breaks down before the fact that the movements can all be changed and the learned path still be correctly followed. Reference has already been made (p. 202) to animals which ran a previously learned maze correctly after cerebellar injury which distorted all their movements. In another experiment (14) a maze was so constructed that it could be flooded with water, either shallow water through which the rat walked or deep water which forced him to swim. After an animal had learned the path walking he followed it correctly while swimming; or *vice versa*. He shifted without confusion from one kind of movement to the other, showing that what he had learned was not a sequence of movements but a path or way through the maze.

Direction learned, rather than a fixed path. We might suppose that the animal was entirely " lost " in the maze, with

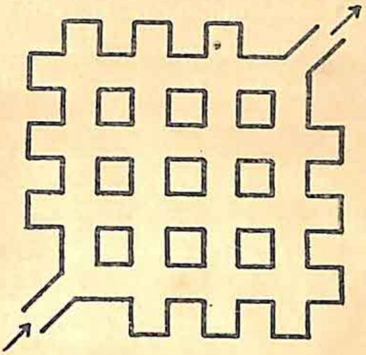


FIG. 53. — (From Dashiell, 6.) An open alley maze. The food box is placed at the exit of the maze.

no sense of direction. But various experiments show that he becomes *oriented* towards the food box within the first few trials, long before he has eliminated all the blind alleys. He is more apt to enter a blind alley which opens toward the food box than one which opens away from it.

In one experiment (6) a maze was used that permitted many alternative routes, all equally long. The animal after

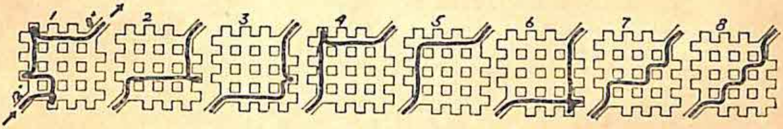


FIG. 54. — (From Dashiell, 6.) An animal's first eight runs through the maze shown in the preceding Figure. He used a variety of routes, many of them equally good.

a few trials headed toward the food box but proceeded by varying routes. He had learned a direction rather than a fixed path.

The locality learned. So far we have considered only the usual form of experiment in which the animal is rewarded on every trial by finding food in the food box; and we have seen that he learns the general direction of the goal and by degrees the path to the goal. If the reward is omitted on the first ten trials, the rat continues his exploratory behavior trial after trial, and seems to be learning nothing. But now introduce the reward — after once finding food in the food box the animal ceases wandering and eliminates the blind alleys much more rapidly than can be done by an animal wholly new to the maze. Evidently exploring teaches the animal the maze as a locality.

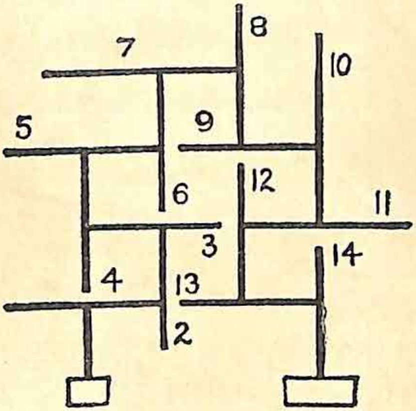


FIG. 55. — (From Tolman and Honzik, 25.) Plan of a multiple T maze, used in experiments on maze running with and without reward. The blind alleys are numbered in order from start to finish.

In a companion experiment the reward is given for the first ten trials and then stopped. The animal immediately drops back into the exploratory type of behavior and enters many blind alleys which he had already eliminated (23).

From these modifications of the maze experiment we see that a rat becomes well acquainted with a locality by exploring it, even though there is no definite goal to steer for; but when there is a goal he steers for it. *What* the rat learns is primarily the place, locale, lay of the land; within this place he learns the direction of the goal and a path to the goal.

The "locality" which the rat learns is not purely an affair of space relations, but is an affair of objects in space, and the animal learns something of the character of those objects as well as of their locations. If the experimenter, between two trials, changes the floor or walls of a passage without altering

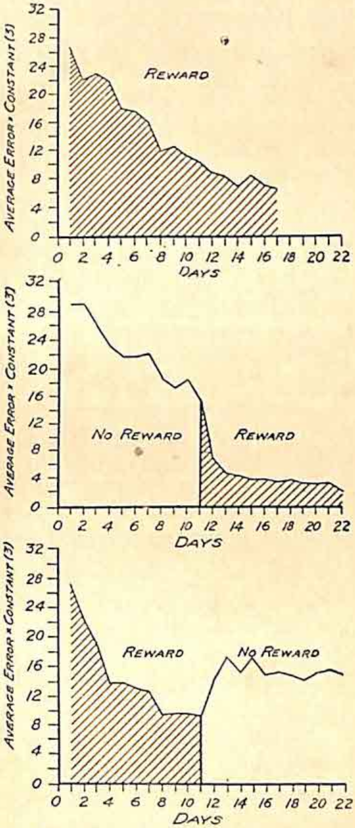


FIG. 56. — (From Tolman and Honzik, 25.) Error curves, showing the number of blind alleys entered on each trial by three groups of rats, running (a) with reward at the end of each trial, (b) with no reward till trial no. 11, and (c) with no reward from trial no. 11 on.

its spatial characters in the least, the rat pauses and sniffs at the novelty; and if many such changes are introduced he may lose his regular path altogether. In the same way the goal is not simply a place, for if a less-desired food is substituted for a more-desired, from a certain trial on, the animal loses some of his urgency to follow the shortest path and begins again to enter blind alleys.

What the rat learns, then, is a *field of objects* that have certain characteristics and certain relative positions, and he learns a path or paths through this field. If he runs the same path very often he may finally build up a fairly definite motor sequence having some of the character of a chain reflex. But the motor sequence is built into the path as the path has been built into the locality.

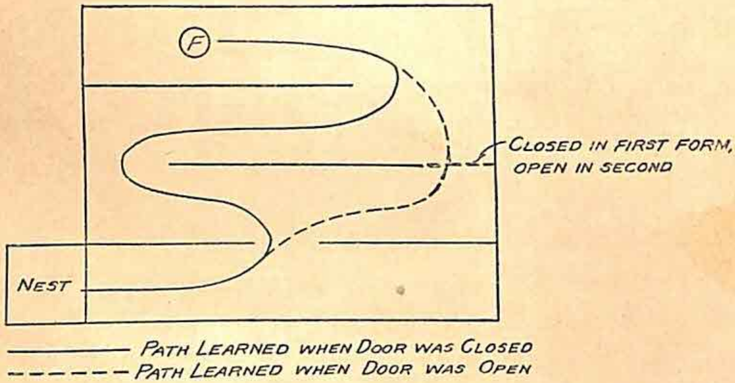

F
Closed in first form, open in second
Nest
Path learned when door was closed
Path learned when door was open

FIG. 57. — (From Aoki, 2.) Chicks first learned to run by the less direct path, and when this habit was well established were transferred to an identical maze provided however with an opening through one partition which gave a short cut. The animals promptly took the short cut.

The statement just made is a fair interpretation of the facts that we have examined up to this point; but we had best take it simply as a hypothesis and see how well it stands up before a few more peculiarities of maze-running behavior which are decidedly interesting in themselves.

Short cuts. If what the animal learned were a sequence of movements or even a fixed path, the opening of a short cut should not change his behavior in a maze already well learned. The ingrained habit should persist. An experiment, this time on chicks instead of rats, shows that the short cut is promptly taken in a simple form of maze (2).

In a more intricate maze, a new short cut will be taken by some white rats, who seem more intelligent than others (19). Consider the complex maze first pictured (p. 226), and note the blind alley that comes to a dead end just in the middle of the top of the diagram. We see from the dotted line that the rat had explored this blind alley at least once; probably he explored it several times. Later he eliminates this blind alley from his path. When he has done so, take away the short partition that separates the dead end of this blind alley from the adjacent part of the correct path. When, on the next trial, the rat comes to this new opening in the side of the correct path, true to the exploring tendency of rats he pauses, sticks his head into the opening and even enters for a short distance before proceeding by his regular route to the goal. On the following trial he uses the former blind alley and comes out at the new opening, so saving much distance. This behavior is not surprising if we credit the rat with a sense of direction and with the ability to learn the lay of the land by exploring a locality.

In a maze provided with two alternative routes, one of them shorter than the other, the rat comes after a time to use the shorter path almost exclusively. In one experiment (10) three routes of differing lengths were present in the maze, only one however being left open in any one trial. The rats, after learning this maze, regularly began each trial by trying the shortest route and entered the longest only as a last resort. Clearly they had learned the locality.

Learning to shift paths at a signal. Suppose we have a very simple maze with only one choice of paths. If the animal once or twice finds food at the end of one of the two passages, he is almost sure to take that passage in the next trial; or if he once gets a (weak) electric shock in one passage he avoids that passage thereafter. He learns simple locations very quickly. But if there is a signal, as a light burning, at the entrance to the passage leading to food, and if that light is shifted irregularly in a series of trials from one passage to the other, the rat may take several hundred trials to learn this trick.

The delayed reaction experiment. This is a complication of the signal experiment, the question now being whether the animal, after thoroughly learning to obey a certain signal, will still obey it even though it disappears before he is free to approach the designated passage. A set-up of three passages opening side by side has been used. The animal is restrained as long as the light is burning and released only after a certain interval of delay. He obeys the signal provided the delay is not too long. With this particular set-up, the maximum delay was about 10 seconds for rats, and 5 minutes for dogs (12). The rats, in this experiment, failed unless they kept their bodies or heads pointed towards the designated passage or unless they continually struggled to go in that direction. Some dogs, however, could shift their position and move about without losing their orientation.

An easier, because less artificial, delayed reaction test has been tried on monkeys and chimpanzees with striking results. The experimenter simply placed two inverted cups or containers on the floor before a monkey and let the monkey see him place a piece of banana under one of the cups. Both cups were then concealed by a large screen for a certain interval, after which the screen was removed and the monkey told to "go get the food." With only occasional errors, the monkey went promptly to the cup covering the food, even when the delay extended to several hours, during which the monkey had been taken from the room. Chimpanzees, after preliminary training, were led from one room to another, each room having in it a pair of containers under one of which the animal saw the experimenter place a piece of banana. After passing through as many as ten rooms in this way, the chimpanzee was brought back to the first room, told to get the food, taken to another room and told the same, and so on; and his score of correct responses ran as high as 90 percent (23, 24).

Place-set and goal-set. The rat pointing at the designated door during the delay after the light has gone out shows the goal-set in a perfectly concrete, visible form. The monkey looks sharply at the cup while the experimenter is placing the banana under it, and undoubtedly locates that cup in the field of objects. He thus becomes set or adjusted for the location of the goal, and is able to carry this adjustment around with him in some invisible form, or to renew it when the field of objects is again presented. The chimpanzee is able to carry around with him several such adjustments to as many different localities (rooms), or to renew each adjustment when he returns to its locality. According to all the evidence, place-set and goal-set are fundamental in maze learning. When the locality and the goal within it are simple and open to inspection, place-set and goal-set are established together and in an instant. When the locality is a maze and the goal hidden, the place-set is built up gradually by exploring the locality, and the goal-set germinates when the reward is first found. We need not suppose that the animal builds up anything like a visual image or map of the locality, for it is sufficient to suppose that his adjustments become active only in the presence of the objective locality and that they are responses to the stimuli received from that locality.

Situation-set or adaptation. Adjustment to a locality is only a part of the adjustment to a total situation. An animal must get used to laboratory conditions before he makes a good subject in a learning experiment. Even the white rat, bred in the laboratory, becomes timid when placed for the first time in a maze or other piece of apparatus. It is standard procedure among animal psychologists to place an animal in some form of maze or similar enclosure for a few minutes every day for a week, and to feed him there, before beginning a maze-learning experiment. This preliminary "adaptation" enables the animal to make much more rapid progress in learning than if he were taken from his living cage without any preliminaries and started right off in the maze to be learned. During the period of preliminary adaptation the animal loses his timidity and is ready to explore freely within a similar piece of apparatus (27).

Wild rats brought into the laboratory never become thoroughly tame and adapted, at least if they are adult when caught. Placed in a maze, they do not explore at all even if very hungry. They cower in a corner or run excitedly to and fro. In short their situation-set is the very opposite of that of a tame animal who is adjusted to the laboratory situation and in good condition for learning (21).

Negative adaptation. Adaptation is called "negative" when it consists in the elimination of positive responses to a stimulus. It is illustrated by an old and well-known experiment on a spider. While the spider was on its web, a tuning fork was sounded, and the spider made its regular defensive response of dropping on its thread. When it had climbed back to its web, the fork was sounded again and the spider dropped again; but after several repetitions in quick succession the spider ceased to drop. Next day, to be sure, it responded as at first; but after several days of this, it became permanently adapted and dropped no more (17).

Negative adaptation may eliminate an avoiding response as in the case of the spider, or an approaching response as in the case of a rat which finally comes to pass the entrance of an attractive blind alley. It is common in domestic animals and in men. The horse "gets used" to the harness, and the dog to the presence of the house cat. Taming consists largely in accustoming the animal to objects that at first aroused fear or a vicious attack. Man becomes adapted to recurring but unimportant noises and other stimuli. Negative adaptation, then, consists in the elimination of responses that are not worth the trouble. It leaves the individual free to deal with the important things, and is evidently an important part of any "situation-set."

Maze learning by human beings. To adapt the maze for experiments in human learning, it has sometimes been built on a large scale, sometimes made to consist of a shallow trough, a foot wide, laid out on the floor, but more commonly it is transformed into a hand maze, the hand pushing a stylus along a groove, or the finger following a pattern of wire fastened to the surface of a board. In all cases the human subject has been blindfolded or somehow prevented from seeing the whole maze at once. There is considerable basic similarity between the human and animal behavior in the maze, though man's initial adaptation is more readily established. The human adult, also, is more deliberate and makes fewer hasty errors. But the chief human peculiarities in maze learning are the following:

1. The use of verbal aids, such as counting the turns and working out a scheme like "right, left, three right, two left," etc. Verbal aids are useful in fixing the details rather than in getting the general orientation and pattern of the path. In some forms of maze, those individuals who resort to verbal aids have a great advantage over those who rely on pure "motor learning" (28).

2. The use of visual schemes or imaginary maps. Comparatively few persons are able to make effective use of this device, but it is found that previous visual acquaintance with a maze greatly facilitates the subsequent blindfold learning of it (26).

3. The use of landmarks. The human subject gives definite testimony of noticing certain parts of the maze as lying on the right path, and of experiencing great satisfaction when he reaches them. They become intermediate goals and he is able to build his path upon them as he does also upon the beginning and end of the maze. He learns parts of the maze in this way and enlarges the parts till they meet. The parts are

learned and combined within the rough framework of the general orientation towards the goal (4). *Fitting together of parts within a pre-existing whole* seems as good a description of the learning process, or at least of some learning processes, as it does of the development of the eye out of several parts within the unitary organism (p. 161).

TOOL LEARNING

Animals, and men to a much greater extent, learn to manipulate objects as means for securing desired ends. As a fundamental experiment here we may take the following.

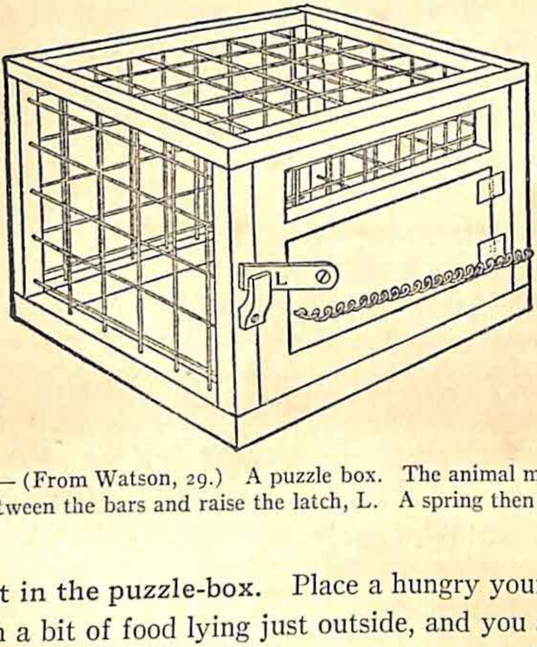


FIG. 58. — (From Watson, 29.) A puzzle box. The animal must reach his paw out between the bars and raise the latch, L. A spring then gently opens the door.

The cat in the puzzle-box. Place a hungry young cat in a cage, with a bit of food lying just outside, and you are sure to get action. The cat extends his paw between the bars of the cage but cannot reach the fish; he pushes his nose between the bars but cannot get through; he bites the bars, claws at anything small, shakes anything loose, and tries every part of the cage. Sooner or later he turns a certain button which lets him out to the fish. The experimenter, having noted the time occupied by this first trial, replaces the still hungry cat in the cage with another bit of fish outside. Same business, with perhaps somewhat quicker escape. Successive trials give irregularly decreasing times of escape, and the useless reactions are gradually eliminated, till finally, on being placed in the cage, the cat turns the button and reaches the food within a second or two. Perhaps 15 or 20 trials, distributed over several days, have been required to reach the final stage of prompt, unerring response to the situation (22).

There is no sign of reasoning in the impulsive behavior of the cat in the cage. There is not even any evidence that the cat notices how he escapes. If at any moment the button stood out clearly as the one tool for opening the door, all the useless acts should cease from that moment, instead of being eliminated gradually. Such observations of means-end relationships as the cat makes must be vague rather than clean-cut.

Learning by trial and error. When an animal has a definite goal but no clear route to the goal, it tries one route after another till something succeeds; and this varied activity is repeated trial after trial with gradual concentration on the successful response. Such trial and error behavior is displayed by the cat in the cage, by the rat in the maze, and by the blindfolded human being in the maze. Man could not get along without trial and error, since often the thing he has to manage is very difficult of rational analysis. Motor skill, as in driving a nail, is typically acquired by trying, failing, varying your procedure and gradually "getting the hang of the thing," without ever clearly seeing what are the conditions of success.

Is trial and error blind or not? As to the end, no; but as to the means, yes. One may see the goal clearly enough or, in the maze, may have at least a definite orientation towards the goal, but be unable to see the path in its entirety.

Human trial and error learning demonstrated in mirror drawing. Anyone can try this experiment with very simple apparatus. Place a small mirror upright on a table, and in front of it a sheet of paper, on which is a star to be traced. Arrange some sort of a screen between your eyes and your hand, so that you can see the tracing movements of the hand only in the mirror.

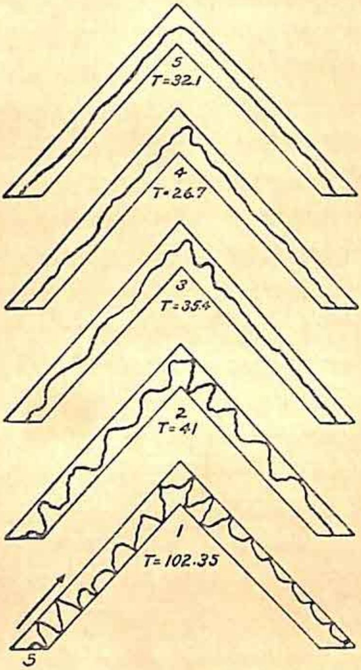


FIG. 59. — (From Snoddy, 20.) The way a beginner negotiated a corner of the star on his first five trials in mirror drawing. The first trial is shown at the bottom and the others in order upwards, the time occupied in each complete circuit being indicated by "T."

Though rational analysis of the mirror effect ought perhaps to enable one to master this performance at once, the well-established habits of eye-hand coordination are not easily reversed, and most subjects find it necessary to resort to trial and error. Altogether baffled and even enraged at first, they soon learn to move slowly and cautiously, checking each false movement before it goes far and allowing any approximately correct movement to take its course. Each false movement brings a pang, each successful movement a momentary thrill of pleasure. Gradual improvement occurs in a series of trials.

The puzzle experiment with human subjects. In place of the simple puzzle boxes used with animals, a mechanical puzzle is of suitable difficulty for the human adult. The puzzle is to be taken seriously, and a "practice experiment" made, the trials being repeated until the subject can manipulate the puzzle quickly and uniformly with no errors or hitches in the performance. At the start of such a practice series, the experimenter hands the subject a wholly unfamiliar puzzle, notes the time required by the subject to take the pieces apart and observes his mode of attack, while the subject reports after each trial what he can remember of his efforts and difficulties.

The human subject's first attack on a puzzle partakes largely of trial and error. Impulsively he tries one possible opening after another, sometimes following the same false lead repeatedly, till, more or less by chance, the pieces come apart to his surprise and gratification. Some few individuals make a more deliberate attack and attempt to study out the puzzle without manipulation; but this apparently rational procedure seldom succeeds because the necessary three-dimensional movements of the pieces cannot be envisaged without actual trial. Rational procedure consists mostly in following through the leads, checking off those that prove futile, and watching for radically new suggestions.

In the second trial the subject may still be at a loss and proceed in the same haphazard manner as at first; but usually he has noticed one or two facts that help him. He is most likely to have noticed at what part of the puzzle he was working when the accidental success occurred; for *locations* are about the easiest facts to observe for men as well as animals. In the course of a few trials the subject eliminates many of the false leads, and may come to "see into" the puzzle more or less clearly, though he may learn to manipulate the thing correctly without really seeing what happens.

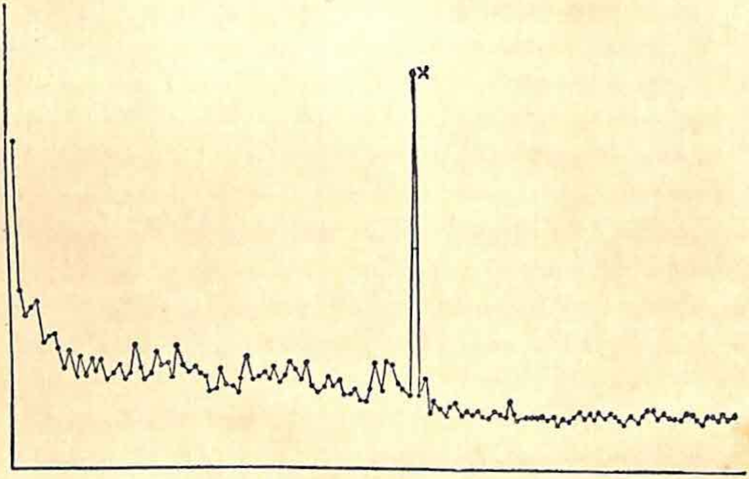


FIG. 60. — (Data from Ruger, 18.) Curve for human learning of a mechanical puzzle. Distance above the base line represents the time occupied in each trial, the successive trials being arranged in order from left to right. A drop in the curve denotes a decrease in time, and thus an improvement. At X, the subject saw something about the puzzle that he had not noticed before and studied it out with some care, so increasing his time for this one trial, but bringing the time down thereafter to a new and steady level.

Insight, when it does occur in working with a puzzle, is of great value. It need not be profound — any clean-cut observation of a significant fact can be classed as insight. Deftness in the handling of a puzzle, or of a tool, often results from close observation of its details.

Learning by "insight" in chimpanzees. Sudden improvement in a performance, resulting from definite observation of facts and relations, has not been clearly demonstrated in rats, cats or dogs, but some instances have been reported from the apes (13, 32). A chimpanzee, after learning to use a stick to help him reach a banana on the floor outside his cage, was given two sticks of bamboo, one small enough to fit into the open end of the other, and the banana was placed too far away to be reached with either stick alone. Could the animal make and use a jointed stick? After over an hour of reaching with the single sticks in various ways, the animal seemed to give up and went to the rear of his cage. While there he shortly began playing with the sticks and by chance, as it seemed, got them end to end and pushed the smaller a short distance into the larger, when he jumped up, ran to the front of the cage, and started pulling in the banana with his jointed stick. When the loosely jointed pieces fell apart, he promptly put them together again and secured the banana. Without stopping to eat, he pulled in everything else within reach of his new tool. When the test was repeated the next day, he began with a few useless movements but in just a few seconds reconstructed his jointed stick and used it as before. The evidence for insight lies in the sudden shift from other behavior to the use of the jointed stick, in the almost complete absence of trial and error on the second trial, and in the animal's interest in the tool itself.

The insight experiment with young children. A child is placed in a nursery play-pen, and an attractive toy is lying on the floor outside the pen, too far away to be reached by the child's arm — but there is a stick inside the pen. After the child has learned without any assistance or suggestion to fish with the stick, both stick and toy are placed outside, but there is now a shorter stick inside the pen for reaching the long stick with which in turn the toy can be reached. When this problem has been solved, the jointed stick test follows, with two pieces of a jointed fishpole substituted for the chimpanzee's bamboo. Here follows the record of a little girl of 40 months in these tests.

Single stick, first day. She handled the stick, talked about it and then dropped it, tried to climb out of the pen; tried to reach the toy by leaning over the top of the pen, and by stretching for it between the bars; sought an exit, repeating over and over, "I can't get birdie"; asked the experimenter to move the toy closer; stepped on the stick, picked it up, banged with it on the wall, and threw it down; tried to reach the toy as before and by pushing her legs out between the bars. As she now appeared tired, the trial was terminated.

Single stick, second day. The child reached for the toy through the spaces, first with the right hand and then with the left, shouting, "To-day, I can get him"; tried to climb out and again reached through the spaces. She stepped on the stick, pounced down upon it, and in ten seconds more had the toy; she repeated the performance for fun.

Two sticks. Child tried to reach the toy with the short stick and in 15 seconds threw it out of the pen. When the experimenter restored the stick, the child said, "Give me the other one, it's better." After a minute she threw the short stick out again and tried to climb out. The experimenter restored the short stick when the child was not looking. Child walked around and tried to reach the toy as before. But at the end of three minutes she reached for the long stick with the short one, and then for the toy with the long stick.

Jointed stick, first day. The child examined one of the sticks and tried to reach the toy with it over the top of the pen; examined the other stick and used it the same way, repeating "I can't" over and over. Tried out a stick between the bars and over the top of the pen, finally striking it viciously against the floor; complained bitterly and tried again to reach as before, stretching and straining; tried to climb out and whined, "I can't." Trial terminated to avoid fatigue.

Jointed stick, second day. Child reached for toy as before and in 10 seconds said, "Look, I can't," but continued her efforts; placed sticks up against bars of pen, banged them together, etc. Tried to reach the toy with her hand through the spaces, to force her way out, to shake the pen, etc.; and finally gave up, saying, "Dolly does not want me to get him."

Jointed stick, third day. For three minutes, she behaved as before, complaining intermittently and finally giving up.

Jointed stick, fourth day. The child stretched for the toy over the top of the pen, striking out angrily with a stick, complaining and asking the experimenter to move the toy closer. After two minutes, she said, "Let's try big stick on little one," picked up the other stick, examined ends carefully and succeeded in fitting them, with a shout of "Bang!" In a few seconds she angled for the toy, reached it exultantly, and repeated the stunt several times (1).

The abrupt transition in these cases from uncertainty to assured mastery came from observing a significant fact or seeing a relationship, i.e., from "insight." With these results in mind, one queries whether observation did not play some part even in the cat's learning to escape from the puzzle-box. The cat was not blindly pawing the air nor thrashing about the cage like a fever patient, but was oriented towards a goal and responding to definite objects in the environment.

But the question is whether, out of the jumble of objects in the total field, the cat ever definitely isolated the little pattern, button-door-fish, and adopted that as his guide of action. Probably not; and probably the rat never got a neat plan of the true course through the maze, as the human subject certainly did not achieve any unitary view of the three-dimensional motion of a complex mechanical puzzle. Partial insights built into a frame of general orientation are about the maximum one can expect of either humans or animals, and with lower animals the insights must be very partial indeed.

THE LEARNING OF COMPLEX ACTIVITIES

We should fall far short of doing justice to human learning if we limited our survey to problems which can be mastered in a few trials. Piloting an airplane, playing a violin or any occupation in which master workmen, virtuosos and "aces" occur by the fortunate combination of natural aptitude and intensive practice, should be examined with the object of discovering what these experts really learn and by what process they reach their high level of mastery. Such studies have been made of telegraphy and typewriting.

Higher units of performance. A student of telegraphy was tested once a week to determine how rapidly he could send a message, and how rapidly he could receive a message by listening to the clicks of the sounder. The number of letters sent or received per minute increased rapidly in the first few weeks and then more and more slowly, giving a typical learning curve.

The curve for sending, aside from minor irregularities, rose in a single broad sweep and flattened out near the "physiological limit," the limit of what the nerves and muscles of this individual could perform.[1] The receiving curve rose more slowly than the sending curve and flattened out after four months of practice, with little further improvement during the next two months — a discouraging period for the student, for he seemed to have reached his limit before coming up to the commercial standard. Many learners drop out at this stage. But this particular student, persisting, found his curve making a fresh sweep upward. It went up rapidly for several months and before it again flattened out at a higher level it had brought him well above the minimum standard for regular employment.

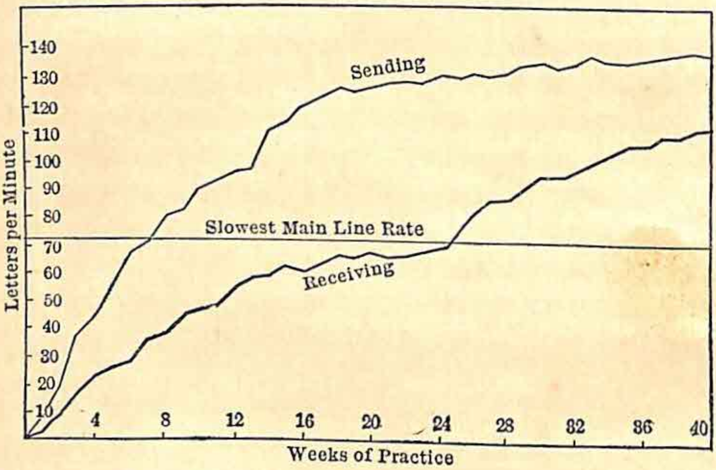


FIG. 61. — (From Bryan and Harter, 5.) Learning curves of student W. J. R. in telegraphy. The height of a curve above the base line indicates the number of letters sent or received per minute. Here, therefore, a rise of the curve denotes improvement.

Such a flat stretch in a learning curve followed by a second rise — such a period of little or no improvement followed by rapid improvement — is called a "plateau." Sometimes due to mere discouragement or carelessness, it often has a deeper cause. It may represent a true physiological limit for the act as it is being performed, and the subsequent rise to a higher level is then the result of *improved methods*.

---

[1] A good example of the physiological limit is seen in the hundred yards dash, since apparently no one can lower the record much below ten seconds. Any given individual's limit may of course be far above this.

It was found that the telegrapher acquired skill by improving his methods more than by simply speeding up his movements. First of all he must learn the letters in terms of dots and dashes. Each letter, in sending, is a little pattern of finger movements on the telegraph key, while in receiving it is a pattern of clicks from the sounder. When he has learned these little patterns, he is able to send and receive, though very slowly. In sending he must spell out the words to himself and write each letter as a separate act. In receiving, at this early stage, he must dissect each letter pattern out of the continuous series of clicks coming to him from the sounder. With practice the letter patterns become so familiar that he goes through this spelling process easily, and concludes that he has mastered the technique and needs only to put on speed.

But not at all! He has acquired only a small part of the expert's technique. He has the "letter habits" but scarcely dreams of the possibility of "word habits." These emerge with further practice. The rhythmical pattern of a whole word becomes a familiar unit. The word need not be spelled out in sending nor laboriously dug out letter by letter in receiving; you simply think the word "train," and your finger taps it out as a complete pattern; or, in receiving, you recognize the characteristic pattern of a long series of clicks. A few much-used words first become units to the learner, then more and longer words, till he possesses a large vocabulary of familiar word patterns. He finds this method of word patterns wonderfully superior to the spelling-out method. He does not even stop with word patterns, but acquires a similar control over familiar phrases (5).

It is much the same in learning to typewrite. First you learn your keyboard and where and with what finger to strike each separate letter. When the letter-striking movements have become easy and sure, you have reached the "letter habit stage," in which you spell out each word to yourself as you write it. With further practice you become able to write any familiar word without spelling it out, by an integrated pattern of finger movements. You write mostly by word units, and in part even by phrase units; and these "higher units" give speed, smoothness and accuracy of performance (3). In telegraphy and typewriting, it is almost inevitable that the learner should master the letters before advancing to the higher units. But in learning to read, children can start with whole words or phrases, mastering the higher units first and proceeding later to analysis of the larger into smaller units.

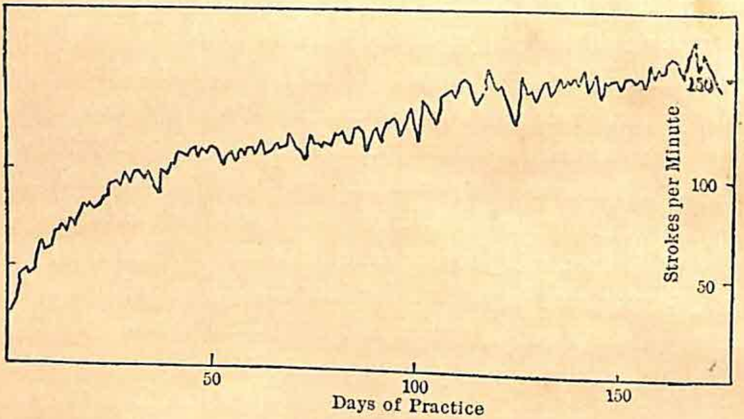


FIG. 62. — (From W. F. Book, 3.) Learning curve of a young man in typewriting. Each point shows a day's record in number of strokes per minute. With improvement, the curve rises.

Practice does not necessarily make perfect. The higher levels of skill are not reached by half-hearted performance, no matter how often repeated. Monotonous repetition simply makes the lower-level procedure more automatic. The only escape to the higher levels comes in moments of intense interest and absorption in an activity. It was in such moments that the typewriting learner hit upon his word patterns.

In the ordinary day's work, we have no clear indication how well we are doing, and no learning curve showing our progress; and we are satisfied if we get through the day easily and without much criticism. Consequently we reach only a moderate level of skill, nowhere near our physiological limit, and never acquire really expert technique. This is as true of the brain worker as of the manual laborer. Evidently motivation — to which topic we will come in a few chapters — is as important a factor in human learning as in that of the laboratory animal. The psychologist can supply motivation for his white rats more effectively than is usually done in human affairs.

THE CONDITIONED REFLEX

We now swing back to the animal field, in order to consider a type of learning which is sometimes called the most rudimentary and fundamental of all.

About the year 1900, the Russian physiologist, Pavlov, while using dogs as subjects in the study of digestion, invented a device by which the saliva from a gland in the dog's mouth was carried out through the cheek in a little tube and could be measured. He then noticed that the saliva flowed rapidly not only when food was actually present in the mouth, but also when the dog saw food before him, or saw the dish in which the food was usually brought, or saw the person who customarily brought him his food, or even heard the footsteps of that person in the next room. With the stimulus of food actually present in the mouth, the salivary response is a natural reflex, but the same response aroused by such a stimulus as the sight of a dish or the sound of footsteps obviously depended on the conditions under which the animal had been previously fed. Pavlov therefore called it a conditioned reflex (16).

The establishment of a conditioned reflex. In the hope of discovering how these conditioned reflexes originated, Pavlov attempted to attach the salivary response to a perfectly arbitrary stimulus such as the ringing of a bell or the flashing of a light. He succeeded by the following procedure.

A hungry dog — a well-treated animal, fully at home in the laboratory — was placed standing on a table but so suspended by slings about his body that he could move only a step or two. While the animal was quiet, an electric bell was started, and when it had rung for a certain time (often for a minute, but a few seconds were sufficient) food was placed in the animal's mouth to make the saliva flow. After a pause of a few minutes, the bell was started again and food was given when the bell had been ringing for the same time. When the sequence of bell . . . food, bell . . . food had been repeated several times, the dog however still remaining fairly hungry, the flow of saliva was observed to start before the food was given. In response to the bell, there occurred a complex pre-feeding activity, including both the glandular response and a motor response of turning towards the source of food. Pavlov's interest centered on the glandular response because it could be measured. As the bell-food combination was repeated time after time, the amount of saliva flowing at the sound of the bell increased to a certain maximum (which was, however, much less than the flow resulting from actual food in the mouth). Thus the conditioned salivary reflex was established for that particular time and place.

Next day there was no flow of saliva at the first sounding of the bell, but it appeared after a very few repetitions; and a few more days of this same procedure established the conditioned response so thoroughly that it held over from day to day.

Extinction or wearing out of a conditioned reflex. We are not to suppose that even a "well established" conditioned reflex has the fixity of a natural reflex. It can be trained out as it was trained in. Simply apply the artificial stimulus repeatedly without the natural stimulus. In one of Pavlov's experiments, the salivary response to a beating metronome was first well established, and then, on a certain day, the metronome was sounded for 30 seconds, bringing a large flow of saliva, but no food was given. On the next trial, three minutes later, the flow was less abundant. Still no food was given, and the same procedure was repeated till the metronome failed to excite any salivary response. The gradual decrease and final extinction of the conditioned response can be seen in the following table of results:

Time when each 30-second stimulation by the metronome began	*Quantity of saliva produced, in drops*
12.07 p.m.	13
12.10 "	7
12.13 "	5
12.16 "	6
12.19 "	3
12.22 "	2.5
12.25 "	0
12.28 "	0

This extinction is only temporary, for next day the metronome again gives a flow of saliva. But if food is omitted this day also, the extinction is more rapid; and repetition of the extinguishing procedure, day after day, finally causes a permanent disappearance of the conditioned response.

The extinction of a conditioned reflex may be fundamentally the same process as negative adaptation. In both we see the gradual elimination of a useless response to a constantly repeated stimulus.

Narrowing the range of stimuli that arouse a certain conditioned response. A new conditioned response, that is working well but has not yet been thoroughly established, is liable to be touched off by a variety of stimuli, as by other sounds than that of the bell which has been used. But after prolonged training with one particular bell, other bells and sounds are mostly ineffective.

A much more rapid method of narrowing the range of effective stimuli is to apply the other sounds without food, and the particular bell with food. Repetition of this procedure establishes two conditioned responses: the positive response of flow of saliva to the particular bell, and the negative response of non-flow of saliva to the other sounds.

Another similar effect may be called the delayed conditioned response. Let the bell always ring for just one minute before food is given. Early in the training process, the saliva starts almost with the bell and flows the nearly whole minute; but as the training progresses, day after day, the onset of the salivary response is more and more delayed till it nearly synchronizes with the food.

Effect of distracting stimuli. We have three classes of stimuli to consider in conditioned reflex work. There is the natural stimulus for a response, there is the "conditioned stimulus," which gives the response after "conditioning," and there may be a distracting stimulus. Any fairly strong stimulus breaking in will disturb the conditioned response, or will disturb any of the negative effects just described. When a conditioned reflex is young, an extra stimulus applied along with the regular conditioned stimulus will prevent the response from occurring. When a previously well established conditioned reflex has been barely extinguished, it reappears as soon as a distracting stimulus is applied along with the conditioned stimulus. When a positive response has been set up to a bell, with non-response to other sounds, a distracting stimulus will cause the positive response to be made to any of the sounds, as if the habit of non-response to these sounds had been thrown out of gear. When a one-minute delayed salivary response has been established, a distracting stimulus coming in during the minute causes the saliva to flow at once, as if the mechanism for holding back the response were thrown out. All these facts fall in line with Pavlov's conception of the non-response as something more than a mere passive absence of response. He thinks of it as an involuntary restraint or *inhibition* of salivary secretion. This inhibition is subject to disturbing influences just as much as the positive response.

So important did Pavlov find the avoidance of distracting stimuli for reliable conditioned reflex work that he secured a special laboratory building with elaborate provision for excluding all extraneous lights and sounds and for keeping the experimenter out of the dog's immediate presence.

Precautions necessary for the establishment of a conditioned reflex. Though Pavlov speaks of the conditioned response as a " reflex," he means only that it is based on a reflex and preserves the stimulus-response character of a reflex, not that it is carried on wholly by the lower nerve centers without participation of the brain. He found it impossible to establish conditioned reflexes in a dog whose hemispheres were removed. The animal's brain must be in good working order. He must be awake. Dogs often go to sleep in a protracted experiment and thus spoil the experiment.

The animal must also be hungry, since a full stomach prevents salivary activity.

The artificial stimulus which you are trying to attach to the salivary response must be fairly strong or at least impressive to the animal. But if it is so strong as to irritate him and arouse a defense response, it does not become attached to the salivary response. The sequence, artificial stimulus — salivary response, must be kept as clean and regular as possible.

The artificial stimulus must slightly precede the onset of the natural response.

Conditioned fear responses. It is a very old idea that an individual's special fears and antipathies are the result of early associations, or in other words of early conditioning. To test out this theory an experiment was tried on a child slightly under a year of age. A rabbit was held out to the child, who showed no fear but reached out to take the rabbit. At this instant a loud rasping noise was sounded close to the child's ear, and the child quickly withdrew his hand with signs of fear. When this procedure had been repeated a number of times, on two days, the child shrank from the rabbit without any further repetition of the noise (30).

This experiment has been tried on a few other young children with varying results. Some children turn around and scowl at the harsh noise, but then return to the rabbit. They seem to hold the noise and the rabbit separate, as if they saw that the noise had really nothing to do with the rabbit. Intelligence may thus prevent a child from learning a multitude of senseless fears.

Other conditioned responses. There are probably many of them, temporary or permanent. Attempts have been made with human adults to condition such reflexes as the knee jerk and the contraction and dilation of the pupil, and the results throw considerable light on the nature of the conditioned response. Take the wink or eyelid reflex, for example. One natural stimulus giving this quick response is a sudden sharp noise. A moderate flash of light, which does not give this response, can be taken as the to-be-conditioned stimulus. Present the light followed by the click, with an interval of a quarter of a second between them. Do this 50 times in the course of half an hour and repeat the whole procedure on successive days. Even on the first day there may occasionally appear a slight lowering of the lid after the light and just before the quick response to the sound; and these anticipatory responses increase in number and extent day by day. This conditioned lid movement however is distinctly not the lid reflex, for it does not have the quickness of that reflex. It is a different type of contraction of the same muscle. It is a preliminary slight contraction of the muscle which, under the circumstances, is just on the point of executing the reflex in response to the sound. Similar results have been obtained with the knee jerk and with the pupillary reflex (9, 11, 31).

Different conceptions of the conditioned response. There are several ways of envisaging the facts.

1. Substitute stimulus. The view is that the conditioned response is the same as the natural response, but is now attached to a new stimulus. The flow of saliva, naturally aroused by food in the mouth, seems to have become attached to the sound of the bell as its substitute stimulus. The fear reaction, naturally aroused by the loud noise, has become attached to the sight of the rabbit. But this conception breaks down in the case of the conditioned lid response, which is not the lid reflex attached to a new stimulus.

2. Anticipatory response. This conception, suggested by the eyelid experiment and similar work, is equally applicable to the salivary response, which was conditioned to start *before* the food entered the mouth, and which was accompanied by a turning of the dog's head towards the customary source of food — clearly an anticipatory type of response. When the food is actually received there is a salivary response much greater than the preliminary flow, and there is also the motor response of eating. The eating movements and the complete salivary response do not become conditioned so as to appear before the food is received. What is conditioned to the bell is the preliminary phase of feeding activity. Similarly, the child's shrinking from the rabbit anticipates the auditory punishment which he has repeatedly received on reaching for the rabbit. The "anticipation" need not be conscious and distinct in any of

these cases; the point is simply that the activity aroused by the sequence of two stimuli becomes, through conditioning, a well-integrated pattern, with an earlier phase preliminary to the main phase.

3. Set or adjustment. If the environment is such that the sound of a bell is regularly followed by food, an advance flow of saliva shows that the animal is adjusted to that environment. When the situation changes and the bell is followed by no food, the extinction of the salivary response shows adjustment to this changed situation. In the other cases, also, conditioning can be conceived as a process of becoming adjusted to the environment, and the experiments can be used as neat examples of the development of a situation-set.

ESSENTIALS OF LEARNING

A general theory of the learning process would appear even more premature now than a few years ago, because recent work has tended to substantiate different theories instead of converging upon any one of them. Let us content ourselves with summarizing the main facts with which theory must square itself.

Association by contiguity. This is an old phrase, meaning that two "ideas" do not become connected "in a person's mind" except by being experienced together. As a negative statement it seems to be true. Translated into terms of stimulus and response, it means that a stimulus does not become connected with a response unless it is present at (or just before) the time when that response is being made.

Repetition. Another old law is that of *use and disuse:* an act is strengthened by use and weakened by disuse. Subordinate to this were the laws of *frequency, recency* and *intensity* or vividness. In stimulus-response terms they state that the more frequently, the more recently, and the more intensely a given stimulus-response unit has been used or exercised, the stronger it is and the readier for action. These laws fit well into our general conception of learning as the development of the individual through his own activity, and they seem to conform quite well with what little we know of the changes of structure induced by activity.

Of late years, many attacks have been made on the assumption that frequency, or repetition, is of itself favorable to learning. To be sure, the conditioned reflex is established only by dint of repetition, but it is also extinguished by repetition without the natural stimulus. The truth may be that repetition by itself neither strengthens nor weakens an act, but simply affords other factors a chance to exert their favorable or unfavorable influence. Accordingly it has been proposed that the way to break an undesirable habit is, not to avoid repeating it, but to repeat it persistently and in cold blood. In line with this suggestion, the habit of writing "hte" for "the" on the typewriter has actually been eradicated by writing "hte" several hundred times, always with the thought that an error was being committed. Some success has even been achieved in curing stutterers by requiring them to practice voluntary stuttering that shall reproduce exactly their own involuntary stuttering. The hypothesis is evidently better than it appears at first thought (7).

Reward and punishment. Learning cannot be explained by repetition alone. In most instances of learning, the environmental factor of reward or punishment is clearly present. The food at the end of the maze, the electric shock in a blind alley, are factors of proved importance. Simple delay in a blind alley is punishment, as shown by the animal's selection of the shorter of two alternative routes. In human maze experiments, the mere success or failure in quickly reaching the goal are sufficient incentives. In establishing a conditioned salivary response, the food is reward, and in extinguishing the same response the absence of food amounts to punishment. Thus reward and punishment play as important a part in conditioning as in trial and error learning.

When the eyelid is being conditioned to respond to a weak flash of light, the reward, or what corresponds to reward, is the final phase of the response pattern, the sharp lid closure at the sudden noise. When the noise is omitted so that the final phase does not occur, the preliminary phase leads to nothing and the whole activity is abortive. The completion of any activity that has been initiated is a rudimentary kind of reward, and the fizzling out of any activity is a rudimentary punishment. One thinks of a sneeze in this connection.

We should not forget, however, that the rat learned the maze as a locality even when there was no food in the food box. What is the reward of mere exploration? Is knowing the locality — or adjustment to the environment — entitled to be called a reward? It certainly means freedom from timidity and uncertainty, and it means readiness for action in that locality. It means freedom to lie down and sleep if there is no call for action. Even negative adaptation is a reward, since it means freedom from unnecessary activity. Ease and readiness are certainly to be counted among the fundamental rewards. In one form or another, it would appear, reward and punishment are always present whenever any learning takes place.

Pattern forming. The higher units in telegraphy and typewriting, the rat's smooth run through a well-learned maze, the sequence of phases in the conditioned response — such patterns are found in all learned activities. In the learning of a performance, the action pattern is at first a mere framework — an orientation towards the goal — but it develops by incorporating parts into this framework. There is first a rather vague adjustment to the situation as a whole, and later, one by one, the various parts of the situation are found and located within the whole. Such phrases as "fitting parts into a framework," or as "grafting parts into an embryonic whole" convey a true picture of the learning process.

REFERENCES

1. Alpert, A. "The solving of problem-situations by preschool children." *Teachers College Columbia Univ. Cont. Educ.*, 1928.

2. Aoki, S. "The primary principle of animal learning." *Jap. J. Psychol.*, 1933, 8, 495–520. Abstract p. 45.

3. Book, W. F. *The psychology of skill.* 1925.

4. Brown, W. "Spatial integrations in a human maze." *Calif. Pub. Psychol.*, 1932, 5, 123–134.

5. Bryan, W. L., & Harter, N. "Studies in the physiology and psychology of the telegraphic language." *Psychol. Rev.*, 1897, 4, 27–53.

6. Dashiell, J. F. "Direction orientation in maze learning by the white rat." *Comp. Psychol. Monog.*, 1930, 7.

7. Dunlap, K. *Habits: their making and unmaking.* 1932.

8. Hicks, V. C. "The relative values of the different curves of learning." *J. Anim., Psychol.*, 1911, 1, esp. p. 142.

9. Hilgard, E. R. "Conditioned eyelid reactions. . . ." *Psychol. Monog.*, 1931, 41.

10. Hsiao, H. H. "An experimental study of the rat's insight within a spatial complex." *Calif. Pub. Psychol.*, 1929, 4, 57–70.

11. Hudgins, C. V. "Conditioning and the voluntary control of the pupillary light reflex." *J. Gen. Psychol.*, 1933, 8, 3–51.

12. Hunter, W. S. "Delayed reaction in animals and children." *Beh. Monog.*, 1913, 2, 1–86.

13. Köhler, W. *The mentality of apes.* 1925. p. 132.

14. Macfarlane, D. A. "The rôle of kinesthesis in maze learning." *Calif. Pub. Psychol.*, 1930, 4, 277–305.

15. Morgan, C. L. *An introduction to comparative psychology.* 1894. p. 53.

16. Pavlov, . P. *Conditioned reflexes.* 1927.

17. Peckham, G. W. & Peckham, E. G. "Some observations on the mental processes of spiders." *J. of Morphol.*, 1887, 1, 383–419, esp. pp. 383–419.

18. Ruger, H. A. "Psychology of efficiency." *Arch. Psychol.*, 1910.

19. Shepard, J. F. "Higher processes in the behavior of rats." *Proc. Nat. Acad. Sci.*, 1933, 19, 149–152.

20. Snoddy, G. S. "An experimental analysis of a case of trial and error learning in the human subject." *Psychol. Monog.*, 1920, 28.

21. Stone, C. P. "Wildness and savageness in rats of different strains." *Stud. in Dynamics of Behavior*, 1932, 1–55.

22. Thorndike, E. L. *Animal intelligence*, 1898, 1911.

23. Tinklepaugh, O. L. "An experimental study of representative factors in monkeys." *J. Comp. Psychol.*, 1928, 8, 197–236.

24. Tinklepaugh, O. L. "Multiple delayed reaction with chimpanzees and monkeys." *J. Comp. Psychol.*, 1932, 13, 207–243.

25. Tolman, E. C., & Honzik, C. H. ". . . Maze learning in rats." & ". . . Maze performance in rats." *Calif. Pub. Psychol.*, 1930, 4, 241–275.

26. Twitmyer, E. M. "Visual guidance in motor learning." *Amer. J. Psychol.*, 1930, 43, 165–187.

27. Warden, C. J. "The value of the preliminary period of feeding in the problem box." *J. Comp. Psychol.*, 1925, 5, 365–372.

28. Warden, C. J. "The relative economy of various modes of attack in the mastery of a stylus maze." *J. Exper. Psychol.*, 1924, 7, 243–275.

29. Watson, J. B. *Behavior*. 1914.

30. Watson, J. B., & Rayner, R. "Conditioned emotional reactions." *J. Exper. Psychol.*, 1920, 3, 1–14.

31. Wendt, G. R. "An analytical study of the conditioned knee-jerk." *Arch. Psychol.*, 1930.

32. Yerkes, R. M. *The great apes*. 1929.

CHAPTER XI

MEMORY

In studying memory, we are continuing the subject of learning. We shall have a chance to test out the generalizations we reached at the end of the last chapter, relative to contiguity, repetition, reward and punishment, and pattern forming. And we shall open up some new questions concerned with the retention and the later remembering of what has been learned. The study of memory has also a very practical side. So much depends on a good memory in all walks of life, and especially in brain work, that it is no wonder students and business and professional men become worried about their memories and resort to memory training courses in the hope of improvement. But just here scientific study is of great practical value, and the best way to go about improving one's memory is to know the facts and laws of memory.

In defining memory, we should first repeat what has been said before, that this noun is properly a verb. The real fact is "remembering." How does remembering differ from thinking? Both make use of past experience. Suppose that a problem — let us say a conundrum — is put to two persons, one of whom has heard it before and remembers the answer, while the other has to think it out. The latter uses past experience, putting two and two together to build up a solution, but the former has a ready-made answer, derived directly from past experience. Memory, then, is a direct use of what has been learned, while thinking is an indirect use of what has been learned. Remembering is performing a previously learned act, while thinking is doing something partially new.

Division of the subject. There are two ways of remembering: *recall* and *recognition.* Recall consists in reproducing material that has been learned, whether this "material" is a picture, a sentence, or an action. Recognition consists in knowing or being acquainted with a previously experienced object. More can usually be recognized than can be recalled. Faces can certainly be recognized more easily than they can be recalled; and often a name cannot be recalled and yet is confidently recognized when heard. Yet sometimes you recall a name correctly, but think you have not got it right; here you recall without recognizing. More than once it has happened that a writer or musical composer has unintentionally plagiarized the work of another, by reproducing what he has read or heard without recognizing it. Recall and recognition are thus different enough to warrant separate consideration, even if fundamentally they may prove to be the same process.

Remembering proves previous learning; and it proves also that what was learned has been *retained* during the interval between learning and remembering. We have then four main subtopics under the general head of memory: Learning, Retention, Recall, Recognition.

MEMORIZING, OR INTENTIONAL LEARNING

In a typical memory experiment, the subject first memorizes certain material; then an interval, longer or shorter, elapses without his doing anything at all with this material; and finally his memory of this material is tested. So far as possible, all the conditions — such as kind of material, length of lesson, rate of presentation, state and attitude of the subject — are controlled. The material must of course be partially unfamiliar, so as to leave something to be learned. Wholly unfamiliar material can scarcely be found, but nonsense syllables, nonsense drawings, disconnected words or numbers, etc., are much used in memory experiments.

The immediate memory span. A short list or series of disconnected words or numbers can be reproduced a few seconds after seeing or hearing it. One of the simplest memory experiments consists in presenting lists of numbers, and discovering how long a list the subject can reproduce perfectly after one presentation. Lists of increasing length are used:

518
3296
70461
927358
4016372
24971306
176028395
6381470259
85079153624
082649138574

Several lists of each length should be tried, in order to allow for slips and flukes. An individual may have no trouble with three, four or five numbers and may succeed every time with six, and usually with seven, but only seldom with the longer lists. His "immediate memory span for digits" would then be approximately seven, about the average for a young adult. Children of four to six have a span of about four digits, and the average increases gradually up to the age of eighteen. It increases also with practice.

Memorizing of longer lessons. If the list of numbers to be memorized exceeds the memory span, several readings are necessary before it can be recited. Of course! — but it is really rather strange. Suppose your memory span is eight digits; why should you not be able to hold eight digits while reading another eight, and then recite the whole sixteen, after a single reading? There is some interference or inhibition. Grasping the second handful, or span of digits, loosens your hold on the first handful. We have here an important elementary fact of memorizing.

Another elementary fact comes to light if you go over the long list time after time. Though for a while it seems beyond your power, with *repetition* it becomes more and more familiar till finally it can be recited without error.

2 6 0 1 3 6 4 2 8 1 9 4 7 6 8 9 0 1 2 7

Mere repetition, however, does not describe the process of intelligent memorizing. The learner is very much on the alert. Suppose he has a list of twenty digits to memorize. As he wades into the long list and finds himself getting out of his depth, he grasps at anything to help. He does not simply take the numbers as they come but looks for *groups* that will hang together. Any familiar group, such as the sequence 1492, he hails with joy. Even if he finds no specially easy spots, he at least notes the *locations* of certain numbers and groups in the list, and he notes similarities and other *relationships* that tie the different parts of the list together.

This process of memorizing conforms very well to the formula suggested by maze learning — "fitting parts into a framework." In memorizing a list, the learner starts with a general impression of its length and make-up, and he proceeds to find parts and to locate them in his framework. The beginning and end of the list, where locating is easy, are usually learned first, but landmarks are soon found in the middle also. The mastered portions grow and finally unite.

Lists of nonsense syllables, such as

wok pam zut bip seg ron taz vis lub mer koj yad

are usually learned by grouping, by observing similarities and contrasts, and by reading meaning into the single syllables or their combinations. Often the subject accents the first syllable of each pair, and finds that the *rhythm* thus introduced aids in memorizing. Many are the devices hit upon, and some of them work better than others, but they all reveal the learner as actively searching for combinations that shall be familiar, meaningful, or somehow characteristic, and thus useful in tying the items together, and in transforming the list from an amorphous mass into a well articulated pattern.

Different types of memorizing. The learner's line of attack differs according to the particular test that is later to be made of his memory. Suppose an experiment is conducted by the method of "paired associates." The subject is handed a list of paired words, such as

soprano ......emblem
grassy ....concise
nothing ......ginger
faraway ......kettle
shadow ......next
mercy ....scrub
hilltop ....internal
recite ....shoestring
narrative .....thunder
seldom ......harbor
jury ....eagle
windy ....occupy
squirm ......hobby
balloon ......multiply
necktie ......unlikely
supple ....westbound
obey ....inch
broken ......relish
spellbound ...ferment
desert ....expect

He must learn to answer with the second word of each pair when the first word of the pair is given. The way he learns this lesson is to take each pair as a unit and look for something in it to bind it together — the mere swing or rhythm of the pair of words, or some connection of meaning. Perhaps the pair suggests a scene or action, however bizarre. A pair that gives a laugh is an easy pair. A few readings fix most of the pairs.

But suppose the experimenter now springs a surprise, by asking the subject to recite the pairs in order. The subject fails almost completely, and protests that the test is not fair, since he has paid no attention to the order of the pairs, but only to each pair by itself. Had he expected to recite the whole list of pairs in order, he would have noted relationships between one pair and another, and perhaps woven them into a sort of continued story. The subject's failure in this last test shows that mere " contiguity " does not suffice to establish connections.

The memorizing of *connected passages* of prose or verse is greatly assisted by the familiar sequences of words and by the connected meaning of the whole, with the result that a connected passage is learned in a fraction of the time needed to memorize the same number of disconnected words. No one in his senses would undertake to memorize an intelligible passage by mere rote learning. For fixing in mind the sense of a passage, the essential thing is to get the sense. Once you see the point, you have learned it.

ECONOMY IN MEMORIZING

Memorizing is a form of mental work that is susceptible of management, and several principles of scientific management have been worked out that may greatly assist in the learning of a long and difficult lesson. The problem has been approached from the angle of economy. Suppose a certain amount of time is allowed for the study of a lesson, how can this time be best utilized?

The first principle of economy has already been sufficiently emphasized: observant study, directed towards the finding and organizing of significant facts, is much more efficient than mere dull repetition.

The value of recitation in memorizing. " Recitation " here means reciting to oneself. After the learner has read his lesson once or twice, let him attempt to recite it, prompting himself when he is stuck. The question is whether this active reciting method of study is economical of time in memorizing, and whether or not it fixes the lesson durably in memory. The matter has been thoroughly tested and the answer is unequivocally in favor of recitation. The results of one series of experiments on this matter are summarized in the adjoining table.

Two facts stand out from the table: (a) Reading down the columns, we see that recitation was always an advantage. (b) The advantage was present in the test conducted four hours after study as well as in the test immediately following the study. Recitation fixes the matter more durably.

THE VALUE OF RECITATION IN MEMORIZING (5)

Material studied	16 nonsense syllables		5 short biographies, totalling about 170 words	
Distribution of learning time	*Percent remembered immediately*	*after 4 hours*	*Percent remembered immediately*	*after 4 hours*
All time devoted to reading	35	15	35	16
1/5 of time devoted to recitation	50	26	37	19
2/5 of time devoted to recitation	54	28	41	25
3/5 of time devoted to recitation	57	37	42	26
4/5 of time devoted to recitation	74	48	42	26

The time devoted to study was in all cases 9 minutes, and this time was divided between reading and recitation in different proportions as stated at the left. Reading down the first column of numbers, we find that when nonsense syllables were studied and the test was conducted immediately after the close of the study period, 35 percent were remembered when all the study time had been devoted to reading, 50 percent when the last $\frac{1}{5}$ of the study time had been devoted to recitation; and so on. The next column shows the percents remembered four hours after the study period. Each subject in this experiment had before him a sheet of paper containing the lesson to be studied, and simply read till he got the signal to recite, when he started reciting to himself, consulting the paper as often as necessary, and proceeded thus till the end of the study period. The subjects in this particular experiment were eighth grade children; adult subjects gave the same general results.

Whence comes the advantage of recitation? For one thing, recitation is more stimulating than the continued re-reading of the same lesson. It provides an immediate goal. Then, each recitation shows you where you have succeeded and where failed. It applies reward and punishment most effectively.

Another advantage of recitation is something a little less obvious. In reciting you perform, as far as possible, the very act you are trying to learn; for you are trying to learn to recite the lesson without the book. To memorize is to perform with assistance an act which you wish to perform later without assistance; and to recite is to do without the assistance now as far as you are able.

Spaced and unspaced repetition. Another question on the economical management of memorizing: Is it better to keep at a lesson till you have it, or to go through it at intervals? This question also has received a very definite answer.

Spaced repetitions are more effective than unspaced. In one experiment (13), a practiced subject went through a list of twenty numbers with an interval of only thirty seconds between readings, and needed eleven readings to master the list. With five-minute intervals, a similar list was mastered in six readings; and the number of readings went down to five with an interval of ten minutes, and remained the same for longer intervals up to two days. With this particular sort of lesson, then, ten minutes was a long enough interval, and two days not too long, to give the greatest economy of time spent in actual study.

In a somewhat different experiment in another laboratory, lists of nonsense syllables were read either two, four or eight times in immediate succession, each day, till a total of twenty-four readings had been given to each list; the memory test was given one day after the last reading of each list. The result appears in the adjoining table.

EFFECT OF SPACED STUDY ON ECONOMY OF MEMORIZING (9)

Distribution of the 24 readings	*Total score of Mr. B.*	*Total score of Mr. M.*
8 readings a day for 3 days	18	7
6 " " " " 4 "	39	31
2 " " " " 12 "	53	55

The widest distribution of the readings here gave the best score; and other experiments have generally given similar results. Undoubtedly, then, if you had to memorize a long poem or speech, you would get better value for time spent if you gave it one or two readings a day, than if you attempted to finish the job at one sitting.

Spaced study also fixes the matter more durably. Every student knows that continuous cramming just before an examination, while it may accomplish its immediate purpose, accomplishes little for permanent knowledge.

When we say that spaced repetitions give best results in memorizing, we do not mean that study should be in short periods with intervals of rest. The probability is, since most students take a certain time to get well "warmed up" to study, that fairly long periods of consecutive study will yield larger returns than the same amount of time divided into many short periods. What we have been saying here is simply that repetition of the *same material* fixes it better in memory, when an interval elapses between the repetitions.

Whole versus part learning. In memorizing a long lesson, is it more economical to divide it into parts, and study each part by itself till mastered, or to keep the lesson entire and always go through the whole thing? Most of us would probably guess that study part by part would be better, but experimental results have usually been in favor of study of the whole.

If you had to memorize 240 lines of a poem, you would certainly be inclined to learn a part at a time; but notice the following experiment. A young man took two passages of this length, both from the same poem, and studied one by the whole method, the other by the part method, in sittings of about thirty-five minutes each day. His results appear in the table.

LEARNING PASSAGES OF 240 LINES, BY WHOLE AND PART METHODS (14)

Method of study	*Number of days required*	*Total number of minutes required*
30 lines memorized per day then whole reviewed till it could be recited	12	431
3 readings of whole per day till it could be recited	10	348

In this experiment, the whole method gave an economy of eighty-three minutes, or about twenty percent, over the part method. Other similar experiments have given smaller differences, and sometimes the advantage has been with the part method. Sometimes, we should add, spaced learning has been found less economical than unspaced.

These contradictions in the experimental results warn us against accepting either spaced learning or whole learning as necessarily advantageous under all circumstances. Rather, we should analyze out the factors of advantage in each method, and govern ourselves accordingly. Among the factors involved are the following four:

(1) The factor of interest and confidence. This is on the side of part learning, especially with beginners, who soon feel out of their depth in a long lesson, and lose hope of ever learning it as a whole. This factor is also often on the side of unspaced as against spaced learning, when there are recitations to keep up the interest; for when the learner sees he is getting ahead, he would rather keep right on than wait for another day to finish.

(2) The factor of recency, of "striking while the iron is hot." When an act has just been successfully performed it can easily be repeated, and when a fact has just been observed it can readily be put to use. This factor is clearly on the side of unspaced learning.

(3) The factor of meaning, outlining and broad relationships. This is on the side of whole learning, for it is when you are going through the whole that you catch its general drift, and see the connections of the several parts and their places in the whole. Even if you incline to the part method, one careful reading of the whole is probably the best way to begin. So you can locate the parts that call for minute examination.

(4) The factor of "growth through activity." This is on the side of spaced learning. The muscles certainly profit more from exercise with intervals of rest than by a large amount of continuous exercise, and no athlete would think for a moment of training for a contest by "cramming" for it. The brain, apparently, obeys the same law as the muscles, and for that reason spaced learning gives more durable results than unspaced.

UNINTENTIONAL LEARNING

What we have been examining is intentional memorizing, with the "will to learn" strongly aroused. The assertion has sometimes been made that the will to learn is necessary if any learning is to be accomplished. We must look into this matter, for it has an important bearing on the whole question of the process of learning.

There is a famous incident that occurred in a Swiss psychological laboratory, when a foreign student was supposed to be memorizing a list of nonsense syllables. After the list had been passed before him many times without his giving the expected signal that he was ready to recite, the experimenter remarked that he seemed to be having trouble in memorizing the syllables. "Oh! I didn't understand that I was to learn them," he said, and it was found that, in fact, he had made almost no progress towards learning the list. He had been observing the separate syllables, with no effort to connect them into a series.

The experiment described a few pages back on "paired associates" is another case in point. The subjects memorized the pairs, but made no effort to connect the pairs in order, and consequently were not able later to remember the order of the pairs.

Similar experiments have sought to measure the *reliability of testimony,* and have shown that the testimony of eye-witnesses is very unreliable except for facts that were definitely noted at the time. Enact a little scene before a class of unsuspecting students, and later quiz them on the facts that transpired before their eyes, and you get an astonishing amount of hazy and even false testimony.

These results all emphasize the importance of the will to learn. But there is another side to the question. An event occurs before our eyes, and we notice certain facts, not with any intention of remembering them later, but simply because they arouse our interest; but later we recall these facts with great sureness. We hear a tune time after time, and come to be able to sing it ourselves, without ever having attempted to memorize it. Certainly the little child learns much in his play and in watching people and things, though with no definite intention of learning.

What is the difference between the case where the will to learn is necessary, and the case where it is unnecessary? In the one case the fact would not be observed, nor would the act be performed, except for the desire to learn it for future use, whereas in the other case the fact is observed or the act performed for some other reason. In both cases the learning consists in observing the fact or performing the act. Learning is not any special kind of activity. Learning a fact consists in observing that fact, and learning an act consists in performing that act. In general, learning consists in going through with the activity to be learned.

THE FIXATION OR CONSOLIDATION OF WHAT HAS BEEN LEARNED

When the active memorizing process ends, is the fixation of what has been learned ended too, or is there a quiet process of consolidation still going on for a few minutes at least — some sort of growth process in the brain, strengthening the mechanism that has been active in memorizing? There is such an after-process in the muscles, and by analogy we might expect it to occur in the brain. This idea was broached before as an explanation of the value of spaced learning. But are there any facts to support this theory of consolidation?

Shock amnesia. If there is such a process, it might be interfered with by a shock, such as a blow on the head. Cases like the following have been frequently reported. A young man, while out in the hills with some friends, fell from a tree upon his head, cutting the scalp and being knocked unconscious for a few moments. He soon recovered enough to walk the three miles to his home, conducting himself in a fairly normal manner, though in a sort of daze, from which he gradually emerged after some hours, with no memory of the walk home, nor of the fall from the tree, nor of a period of some fifteen minutes *before* the fall. The shock effect, then, was retroactive; it caused an amnesia (loss of memory) for events that happened just before the shock, as if it checked a process of consolidation. The amnesia for what happens during high fever, or during intoxication, may similarly be due to abnormal brain conditions preventing consolidation.

Retroactive inhibition. Consolidation might be favored by a restful, easy occupation immediately after memorizing, and might be disturbed and partially inhibited by strenuous mental activity just then. Experiment has shown that such is the fact. For example, the position of five chess men on the board was studied for fifteen seconds, and then the subject immediately shifted to adding columns of numbers, keeping this up for a minute, after which he attempted to reconstruct the arrangement of the chess men. The interpolated activity increased the number of errors by 50 percent over what it was when the subject simply rested during the interval (16). There are many similar experiments with various memory tasks, and on the whole, they give evidence of retroactive inhibition, though sometimes the effect is very slight. The greatest inhibitory effect is obtained by shifting from one memory task to another calling for the memorizing of similar material.

Perseveration. If you have been busy with certain material, it may " bob into your head " at odd moments a little later. A tune may persist in " running in your head " when you wish it would stop. Scenes from the day's experience may flash before your " mind's eye " as you lie in bed before going to sleep. Important news, submerged during strenuous mental work, emerges as soon as there is a moment of relaxation. A recent activity that thus reasserts itself, without any apparent cue or stimulus to arouse it, is said to " perseverate." Some persons are much more subject to this perseveration than others.

The tendency of interrupted activities to perseverate.

If you are prevented from completing an activity in which you have got well started and absorbed, this activity is specially likely to show perseveration. Such, at least, is the indication of a memory experiment which dealt with the question in a novel way (19). The experimenter gave the subject a series of little tasks, each of which required a few minutes to complete. Specimen tasks were: to write down from memory a favorite poem, to model a dog in clay, to draw a vase with flowers according to the subject's taste, to multiply two four-place numbers, to solve a riddle. About twenty tasks were given but half of them were interrupted by the experimenter removing the materials and saying, "That is enough for that, now turn to this other task." As soon as the series had been gone through, the subject was asked to name all the tasks, and it was found that about 68% of the interrupted tasks were recalled, and only 43% of the completed. The interrupted ones seemed to be left in a condition of readiness for renewed activity.

All in all, though the evidence for a consolidating process following active learning is rather scrappy and inconclusive, we have to reckon with the probability that a vivid experience, an intense activity, is likely to persist in some form for a few minutes at least. During this time, we may well believe, it deepens its "memory trace" in the brain structure.

The effect of reward and punishment on fixation. The experimenter (17) provides a list of 40 words, each paired arbitrarily with some number from 1 to 10 (see sample below). After reading the list of pairs once through very rapidly to the subject, to give him a slight start, the experimenter speaks the stimulus words and the subject responds instantly to each word by saying some number from 1 to 10. If he chances to say the assigned number in response to any word he is "rewarded" by being told "Right," otherwise he is told "Wrong" without being told the right answer. The series is gone through several times in this same way, in order to see whether the subject tends to repeat rewarded responses and to avoid those that have been punished. The result is that the rewarded responses are very commonly repeated, while the punished responses also tend to be repeated to some extent. The most interesting result, however, is that a punished response occurring close to a rewarded response is more likely to be repeated on that account. Here is a small part of one of the lists used, with one subject's responses in four successive trials:

Stimulus word	*Right response*	*Subject's responses in trials*			
		1	2	3	4
fancy	3	4	7	5	3
fearful	8	2	3	10	8
filter	6	9	9	7	4
flagon	9	10	10	9	10
gamble	2	4	2	1	4
garter	10	8	6	5	4
ginger	9	6	9	9	9
glitter	1	2	3	3	3

The response to "ginger" was rewarded on the second trial and the same response was repeated on the third trial, and also on the fourth. The response to the following word, "glitter," though punished, was repeated, as if the effect of the reward carried over to the following item. In other cases it carried back to the item preceding the reward. Single cases prove nothing in an experiment of this sort, but with 10 subjects and 14 lists of 40 words, data were obtained in sufficient quantity to give reliable statistical differences. These came out as shown on the following page.

A punished response was repeated in the following trial in 21 percent of the cases, in general, but if it came next before or after a rewarded response it was repeated 27 percent of the time. Thus there is a slight but definite tendency for the in-

	Percent of responses repeated in the following trial
Rewarded responses	67
Punished responses adjacent (before or after) to rewarded responses	27
Punished responses situated two steps from a rewarded response	24
All other punished responses	21

fluence of a reward to extend to responses close to the response which it was intended to reward. The strengthening effect of the reward, or of the momentary glow of satisfaction induced by the reward, was not always confined to the nearest response. In terms of "growth through activity," we can say that the structural pattern which executes a particular activity is favorably affected by a reward coming immediately after the activity (as in the case where the rewarded response is strengthened) and also in some cases by a reward occurring a little earlier or later.

RETENTION

We come now to the second of our four main topics, and ask how we retain, or carry around inside of us, what we have learned. Retaining is certainly not a continued repetition of the learned performance. The boy who has learned to say the multiplication table, and also to turn a handspring, does not have to keep performing these acts "unconsciously" in order to retain them. Retention is a resting condition in which anything that has been learned remains till called into activity again. What we directly retain is structure — structure modified by activity. We postulate modified structure, but our evidence of retention is found in modified activity, i.e. in activity which shows the effects of earlier activity. The facts, in the investigation of retention, are the remembering — and the forgetting — of what has previously been learned.

But is anything once learned ever completely forgotten and lost? Some say no, being strongly impressed by the occasional recovery of memories that were thought to be gone forever. Experiences of early childhood have sometimes been recovered after a long and devious search. Persons in a fever have been known to speak the language of their childhood which in their normal state they could not remember at all. Such facts have been generalized into the extravagant statement that nothing once known is ever forgotten. For it is an extravagant statement. It would mean that all the lessons you ever learned, all the stories you ever read, all the faces, scenes and happenings that ever attracted your attention are still retained and could be recalled if only the right means were taken to revive them. There is no evidence for any such extreme view.

The relearning method of measuring retention. You can prove your memory by recall or by recognition; and there is also a third way. If some time ago you memorized certain stanzas of a poem, it may be that you cannot now recall any of the lines; it may be you cannot even recognize or identify the stanzas you once learned; but you may find that you can now learn certain stanzas more easily than the rest, because you are *relearning* what you learned before. If it took you ten minutes to memorize a stanza originally, and now takes you only eight to relearn it, then retention is responsible for a saving of two minutes in relearning. The labor of relearning has been reduced by 20 percent through retention of the effects of the former learning, and the retention, as measured by the *saving*, amounts to 20 percent.

The retention curve, or "curve of forgetting," was first obtained by the relearning method and later verified by use of the recall and recognition methods. The curve shows a gradual loss of retention with the lapse of time. But the rate of forgetting is not constant; rather, it is rapid at first, immediately after the end of the learning, and becomes slower and slower.

Though the general shape of the curve is well established by numerous experiments, the absolute speed of forgetting varies enormously in different cases. One individual forgets more rapidly than another. Material that has been "over-learned," i.e., studied beyond the point where it can barely be recited without error, is forgotten more slowly. Most important of all, meaningful material, besides being much more quickly learned than nonsense material, is much more slowly forgotten. Nonsense material, barely learned, is almost entirely lost by the end of four months, but poetry, barely learned, has shown a

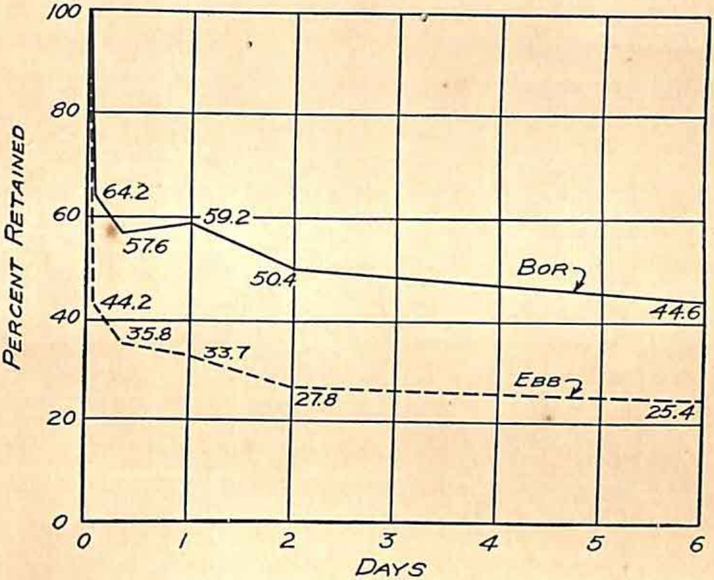


FIG. 63. — (From Ebbinghaus, 3, and Boreas, 2.) The curve of retention, or of forgetting. Lists of nonsense syllables were memorized, laid aside, and relearned after the stated intervals. The Ebbinghaus curve is from one individual subject, who however learned many lists; the Boreas curve is the average from 20 students, each learning one list for each interval. While the Boreas curve shows much slower forgetting than that of Ebbinghaus, both curves have the same general shape.

perceptible retention after twenty years. Material that is both meaningful and greatly "over-learned" may stick almost indefinitely with little apparent loss. A student who had practiced on the typewriter for two hundred hours, and then dropped it entirely for a year, recovered all the lost ground in less than an hour of fresh practice, so showing a retention of over 99 percent.

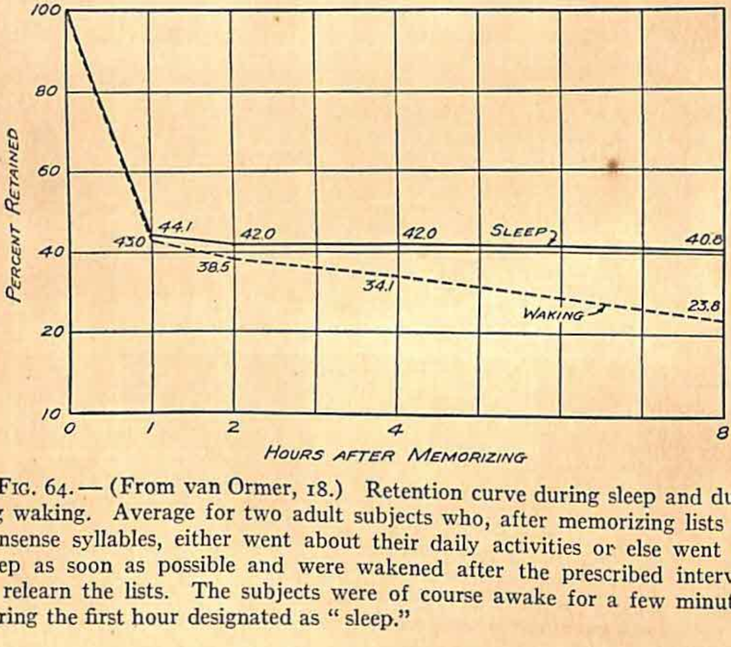


FIG. 64. — (From van Ormer, 18.) Retention curve during sleep and during waking. Average for two adult subjects who, after memorizing lists of nonsense syllables, either went about their daily activities or else went to sleep as soon as possible and were wakened after the prescribed interval to relearn the lists. The subjects were of course awake for a few minutes during the first hour designated as "sleep."

Slow forgetting during sleep. A sleep of four or eight hours following directly after memorizing slows the forgetting of the learned material. This result has been obtained in several experiments directed to this particular question; and there is some sign of the same effect in Fig. 63, since the amount forgotten after twenty-four hours (part of which were spent in sleep) is less than would be expected from the general run of the curves.

The cause of forgetting. Forgetting cannot be due to the mere lapse of time. It is not time, but only what occurs in time, that can produce effects. Nor can the mere disuse or inactivity of any structure be supposed to have any effect. It must be a process of some sort which weakens and finally destroys retention. It would seem to be a process which is less active during sleep than during the day. These considerations, along with the fact of retroactive inhibition, suggest that it is the interference of one activity with another which causes forgetting. Intense activity may interfere with the consolidation of what has just been learned. This destructive process could account for the rapid forgetting that takes place immediately after memorizing has ceased, but not for the slow subsequent decline of retention. But we can imagine that the structures developed into a certain pattern by activity are likely to be drawn into other patterns by later activity, so that the original pattern is slowly washed out.

On what might be called the "sleeping beauty theory of retention," nothing would be lost from memory in a period of total mental and motor inactivity. But if the organism remained alive, we must suppose its metabolic activities to continue, and they would slowly alter the structural patterns developed by previous activity, as they alter the inactive muscle and cause it to lose substance and power. Forgetting, in a sense, is a return to normal, analogous to the healing of a wound.

How to avoid forgetting. Sleep, or "take it easy" for a time after memorizing something important, would seem a hopeful suggestion from what precedes. Another rule is — Review. When what has once been memorized and partially forgotten is relearned, the curve of retention is found to drop more slowly than before, and more slowly after each successive review. Well learned material can be permanently retained by reviews spaced at long intervals.

The rules for economy of memorizing hold good also for retention. Forgetting is slower when relationships and connections have been found in the material than when the learning has been by rote. Forgetting is slower after active recitation than when a more passive method of study has been employed. Forgetting is slower after spaced than after unspaced study, and slower after whole learning than after part learning.

An old saying has it that quick learning means quick forgetting, and that quick learners are quick forgetters. Experiment does not wholly bear this out. A learner who learns quickly because he is on the alert for significant facts and connections retains better than a learner who is slow from lack of such alertness. The wider awake the learner, the quicker will be his learning and the slower his subsequent forgetting.

How to forget. The obvious answer, from what precedes, is, Don't review. But is there anything more that one can do? Is there such a thing as "active forgetting"? There are painful experiences that we should like to erase from memory, especially experiences that hurt our pride and self-respect, and if psychology could show us any way of killing these memories, we should like to use it. Some persons have a way of violently *repressing* such memories, and producing a genuine amnesia for them. It is a recall amnesia rather than a retention amnesia; the repressed material, though inaccessible most of the time, may reappear under hypnosis or psychoanalysis, or in dreams or daydreams, or in a sort of trance or hysterical attack which these persons are liable to have from time to time. The process of repression is not well understood, and psychology cannot tell the anxious inquirer exactly how to go about it. But so much as this is clear, that it is an unmanageable process which carries into the discard more than the subject means to lose. It carries away useful material that is associated with the painful experience; it may involve loss of appetite, or loss of the use of a hand or of the eyes, just because these activities are tied up with the experience which is violently thrust out of memory. So this type of active forgetting is not to be recommended for general use. If involved in something we shall hate to remember, the best rule is to face the facts, think them through, do what needs to be done, and reach a satisfactory adjustment before laying the matter aside. By completing the task now we avoid perseveration and later forced reviews.

RECALL

Learning does not guarantee later remembering, for retention may have fallen too low to permit of recall. But even good retention does not guarantee recall. We know a person's name, as is proved by our recalling it later, but at the moment we cannot get it. We know the answer to an examination question, but in the hurry and worry of the examination we give the wrong answer, and only later does the right answer come up. Some sort of inhibition or interference blocks recall in such cases.

Interference in recall. One type of interference is emotional. Fear may paralyze recall. Anxious self-consciousness, or stage fright, has prevented the recall of many a well-learned speech, and disturbed many a well-practiced act. Another type of interference occurs when two acts are both aroused at the same time, and get in each other's way. You will sometimes hear a speaker hesitate and stumble because two ways of expressing his thought occur to him at the same instant. One recall blocks the other. Something of the same sort often happens when you start to recall a person's name. You get some other name which is more readily aroused at the moment, and, thus put off the track, labor in vain to reach the right name. Drop the matter, and a little later the desired name is recalled without trouble, because the interfering activity has quieted down and lost its temporary advantage. This plan of dropping the matter when one is baffled and confused, and taking it up again when fresh, works well in other cases besides hunting for a name.

Partial recall. Imperfect recall is likely to be falsified rather than merely fragmentary. For example, a name eludes us; we have it vaguely but it will not take definite shape. However, something does take definite shape, some complete name emerges, only it is not the name we want. In the list of cases below, contributed by several individuals, each line contains the name first recalled, followed by the true name that was sought.

Manning — Mayo
Bogert — Burgess
Macdonald — McDougall
Hennessy — Haggerty
Stoop — Cole
Ernst — Stern
Barclay — Clayton
Adleman — Wadleton
Balboa — Bonivard
Sonnenschein — Sonneborn
Kohlrausch — Rauber-Kopsch
Underwood — Overstreet
Poseidon — Parmenides
O'Rourke — McCrea
Guy Lussac — Ives Delage

Examination of these and many other samples shows that the erroneous name recalled commonly preserves the general character of the true name — the language or nationality, the number of syllables and accent, and the initial sound. In these cases of hampered recall, one seems to be oriented towards the goal but to have strayed into a blind alley. The falsely recalled name probably has an advantage in frequency or recency.

A still better experiment on partial recall is one with nonsense drawings, which are shown for a moment and reproduced from memory. The general shape of the drawing is more apt to be reproduced than the details. A drawing observed to resemble any familiar object is so modified in recall as to better represent the object. Details which made little impression on the observer drop out, leaving the figure more compact and simple. Much the same is certainly true of the recall of events

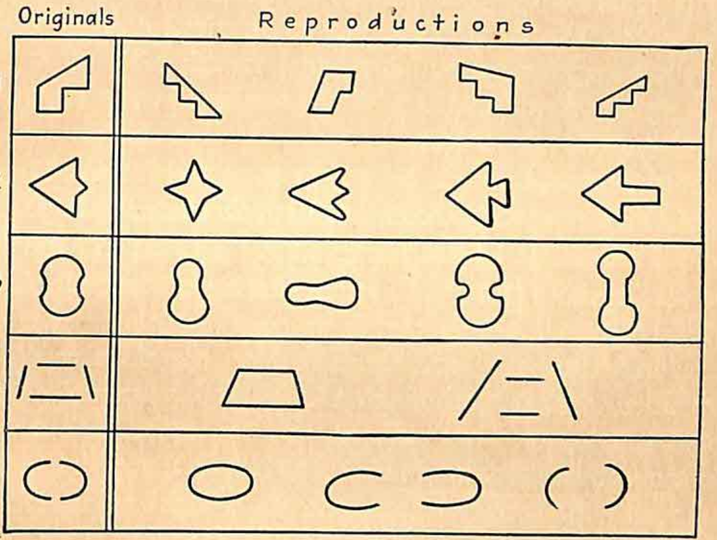


Fig. 65. — (From J. J. Gibson, 6.) Attempts to reproduce nonsense figures after a brief exposure of a series of fourteen of them. The left-hand column here shows some of the nonsense figures that were shown. The first one usually suggested stairs, but once a ship's ventilator. The second was seen as a star, as a bird flying, as an arrowhead, and as an arrow. The third was seen as a woman's torso, as a footprint, as a violin, and as a dumb-bell. In reproducing the broken figures, the subjects sometimes neglected the gaps, and sometimes overdid them.

and experiences: the impressive facts remain, less impressive facts disappear, and the whole story is rounded out. When any emotional bias adds its distortion, the resulting memory may be very wide of the original events.

Recall of childhood experiences. Most experiences of early childhood are forgotten before adult years, to judge from the meager result of casually trying to recall them. The farther back you go, the fewer incidents you can recall. From all the vivid experience of very early childhood scarcely anything can be recovered.

However, if you assemble all available aids to memory — pictures and objects connected with your childhood and incidents reported by your parents and friends — and immerse yourself in this material, you may be surprised at the revival of long-lost impressions and incidents, though after all it is a meager harvest compared with the wealth of early experience which you do not recover.

Several special devices have been employed for assisting the subject to revive early memories, all of them aiming to put him into a relaxed and half-dreamy state. Hypnosis is one such device; another is crystal gazing (staring abstractedly into a glass ball), and still another is automatic writing, which consists in letting the hand write without conscious control or attention to what is being written. You ask your subject questions bearing on his childhood, and he replies in automatic writing, or sees pictures in the crystal; and, though he may not recognize the incidents thus brought to light as his own experiences, testimony from parents may verify them. Such probing has been attempted in the hope that revival of early memories would afford the means for correcting abnormal fears or other unfortunate twists in the personality dating from early childhood; but the results are only moderately encouraging (10, 11).

Memory images. If a recalled fact or experience comes back with a decided sensory character — if it is realistically like actual seeing or hearing or smelling, it is called a memory image. Can you recall the blue of the sky, or the tone of the violin or of a friend's voice, or the odor of camphor, or the feel of a lump of ice in the hand, or the way it feels to jump, or kick, or yawn, or clench your fist? Almost everyone will answer "Yes" to some or all of these questions. One will report getting a vivid picture of a scene, and another a realistic mental rehearsal of a piece of music. What they recall seems to them essentially the same as an actual sensory experience.

Individuals seem to differ greatly in the vividness or realism of their memory images, as was brought out in an earlier chapter (p. 32). Some psychologists, who prefer to admit only strictly objective data into the science, deny the existence of memory images, or seek to explain them away as combinations of present sensory experience and motor response; but these theories do not ring true, and the fact certainly seems to be that sensory experience as well as motor activities can be revived or recalled.

Most memory images, indeed, are inferior in realism and completeness to actual sensory experience. From the practical standpoint they are inferior in that facts cannot be found in the image of a thing unless they were observed in the actual presence of the thing.

At one of the universities, there is a beautiful library building with a row of fine pillars across the front, and the students pass this building every day and enjoy looking at it. A favorite experiment in the psychology classes at that university consists in first asking the students to call up an image of the front of the library, and then asking them to count the pillars from their image. But at this point the students begin to object. "We have never counted those pillars, and cannot be expected to know the number now." In fact, few of them give the correct number, and those whose images are vivid and realistic are little better off in this respect than those whose images are dim and vague.

Ordinarily, in looking at a beautiful building, we simply take in the general effect; and when we later get an image, it is just this general effect which we recall. If we pick out details, we can later recall them. If we study the color scheme, or the balance of masses, while looking at the building, we can recall what we have observed and no more.

The primary memory image — eidetic images. What has been said of images, so far, refers to those recalled some time after the original experience. The primary memory image is different in that the experience is simply persisting for a few moments after the original stimulus has ceased. For a few seconds after somebody has stopped talking, you can still hear his voice, as if in an echo, even though you cannot usually recall sounds with any distinctness. You may be able to recover what he has said, though you were not closely attending to it at the instant when he was speaking. In the same way, immediately after you have looked over the landscape out of your window, you can still see it better than you can recall it later. This primary memory image is not the same as the "after-image" or after-sensation to be described later under the head of sensation.

Now it appears that many children under fourteen years of age, perhaps half of them, if they examine any complex object or picture in an absorbed way for half a minute, and then shut their eyes, or, still better, turn them upon a plain gray background, can *see* the object as if it were still before them, and can answer questions about it which they did not have in mind during the actual presence of the object. This image is not strictly photographic, but rather plastic, and likely to be modified by the subject's interest. The object may grow larger, or may become more regular, or may appear to move. The color may become more brilliant, or may change to a different color. Such changes may be either voluntary or involuntary. This type of image, then, is quite subjective, though on the whole it conforms rather closely to the scene from which it was taken.

These peculiarly vivid and detailed primary memory images have been called "eidetic images," and the individuals who have them "eidetic individuals." Eidetic imagery seems to be most common in later childhood, and to fade out, usually, during adolescence, though a few adults can still obtain images of this sort. Such images, though usually appearing, if at all, immediately after being immersed in the actual contemplation of an object, may perseverate and reappear later (1, 8, 12).

Hallucinations. Since a vivid memory image may be "in all respects the same as an actual sensation," according to the testimony of some persons, the question arises how such an image is distinguished from a sensation. Well, the image does not usually fit into the objective situation present to the senses. But if it does fit, or if the objective situation is lost track of, then, as a matter of fact, the image may be taken for an actual sensation.

You are half asleep, almost lost to the world, and some scene comes so vividly before you as to seem real till you awaken to the reality of your surroundings. Or you are fully asleep, and then the images that come are dreams and seem entirely real, since contact with the objective situation has been lost.

Images taken for real things are common in some forms of mental disorder. Here the subject's hold on objective reality is loosened by his absorption in his own fears and desires, and he hears reviling voices, smells suspicious odors, or sees visions that are in line with his fears and desires.

Such false sensations are hallucinations. A hallucination is a memory image taken for a sensation, it is something recalled or built up out of past experience and taken for a present objective fact.

Synesthesia. A considerable number of normal persons have the peculiarity of hearing sounds as if also having color, a deep tone sounding dark blue, it may be, a trumpet bright red. Each vowel and consonant may have its own special color, and a word may have a color scheme built up out of the colors of the letters. Numbers also are likely to have their colors. Colored hearing is the commonest, though not the only form of synesthesia, which consists in responding to a stimulus acting on one sense by sensations or images belonging to another sense. The synesthesia probably originated in childhood from playfully linking the different kinds of sensation together.

Recall as a response to a stimulus or cue. The sight of a person calls up his name, or his name when he is absent calls up a memory image of his face. In these and other typical cases, recall is a response to a cue, and it is reasonable to believe that a cue is always necessary. Perseveration, indeed, is an exception.

In recall the individual does something that he has previously learned to do; he makes a response that he has previously learned to make. But the situation to which he now responds differs in one important respect from that in which he learned the response. In learning a poem he had the book before him, but now he recites it without the book. Surely he must have some cue or cues in recall that were present in the learning situation. If he once memorized Hamlet's soliloquy, what is his cue to recite it now? The title of the selection starts him on the first line, and each successive line may be sufficient to call up the next in order. Probably, however, his recitation is not a mere "chain reflex." Probably he is oriented in the selection, and has the general sense and trend of the whole soliloquy as a guide. At any rate, some *part* of the original situation is now present to serve as a stimulus to recall. Recall, then, consists in doing something in response to only a fraction of the situation that first aroused the response. In recall we respond to "reduced cues" (7).

RECOGNITION

The same questions that we have been trying to answer regarding recall we should now ask regarding recognition. What sort of activity is recognition, and how is it aroused? What is this type of response, and what is its stimulus?

When recognition is quick and easy, it is elusive and difficult to describe; our best chance for success will lie in cases where the process is not so easy or where it goes wrong.

Direct and indirect recognition. Odors have been used in experiments on recognition, just because they are not, as a rule, so easily and quickly recognized as are objects seen or heard. A theory to be tested in these experiments held that recognition was accomplished by the recall of the original setting of the odor in some past experience. A certain odor might recall to mind a mountain-side, and so lead to its recognition as the odor of a mountain flower. This indirect type of recognition does occur, but seems to be much less common than the direct sort, in which the odor is known before recall of the past experience has time to take place. Therefore, the theory mentioned cannot be accepted as a general description of the process of recognition (4).

Partial recognition. Sometimes recognition is slow, and attended by curious feelings. You see some one who looks familiar, and feel that you must have seen him before. This *feeling of familiarity* haunts you till you can remember more about him. The person may seem not simply familiar, but as if you had seen him recently, or a long time ago, or as if you had been amused by him, looked up to him, been on your guard against him, or bought something of him. Such impressions often turn out to be correct, and they amount to partial recognition. The attitudes of amusement, deference, hostility, etc., revived in partial recognition were originally aroused by the individual as he conducted himself in a certain setting. When we later see the person apart from all the rest of the original situation, some of our original response is awakened. To judge from such cases, the response in recognition may be the revival of any attitude or other response formerly aroused by the object now recognized; and the stimulus to recognition may be but a fragment of the situation which originally aroused this response, so that recognition, as well as recall, gets along with much reduced cues.

Errors of recognition. Recognition is not infallible by any means. If an object now presented *resembles* one seen before, there may be false recognition. In one experiment, pictures are shown one after another, and later shuffled together with other pictures, some of which are quite similar to those shown, while others are very different; the whole mixed lot is now presented, one picture at a time, and the subject is to say "Yes" to those he recognizes and "No" to those that seem new. He says "Yes" to many that are only similar to what he saw before, and even to a few that are very different from any he saw before, but these false recognitions are slow and lacking in confidence. He also makes errors of the reverse kind, by failing to recognize pictures that were actually shown him before, and this sort of false response also is slow and doubtful, on the whole. The correct recognitions, on the other hand, are usually quick and confident. But the quickest and surest responses of all are the "No" responses to the new pictures. Non-recognition, then, or the knowing of a thing to be new, is not a mere absence of recognition, but is a quick, definite, emphatic action (15).

To make sure of later recognition of an object, you need to make some distinctive response to it now, to notice for example how it differs from other objects with which it might be confused. Ordinary casual observation of faces is not enough to insure recognition later. In the studies of errors of testimony, already spoken of, the identification of persons only casually observed has been found extremely unreliable.

Disorders of recognition. When one is in a let-down state, and far from alert and keen, even a decidedly novel situation or happening may arouse a feeling of familiarity, a weird feeling that one has been through all this before, as if time had slipped a cog and were now repeating itself. Perhaps fifty percent of young people can remember having had this queer experience, and some few individuals suffer from it a great deal. It may be called the "illusion of having been there before."

The opposite illusion, called the "feeling of strangeness," also occurs in some abnormal conditions. The subject uses familiar articles well enough, and knows the names of his family and friends, but he insists that people, places and objects all seem new and strange to him, and naturally enough he is much disturbed. A full explanation of these illusions of recognition is not known.

Recognition compared with recall. The baby smiles at a person who has pleased him before, and shrinks from one who has displeased him, and thus shows recognition of both. The same can be said of the dog who barks at the door bell, though his mouth waters at the dinner bell. Recognition may consist simply in reviving these responses to these objects. According to this conception, an object is recognized if it re-arouses a response that was previously attached to that object by a process of learning. The baby's smile was first attached to a certain person when that person was doing something to please him. Later, the baby shows recognition by smiling as soon as the person appears, without waiting for anything amusing — another case of reduced cue. The recognition consists in the smile aroused by this reduced stimulus. The smile itself may later be reduced, so that an adult, on suddenly encountering a person who has sometime amused him, has a feeling of amusement and thus (partially if not completely) recognizes the person, without the necessity of openly grinning in his face.

According to this theory, recognition consists in the recall or revival of any response that was attached to the recognized person in previous experience. In one instance recognition of a person consists in a revived amusement, in another instance it consists in the recall of the person's name. A present object may arouse the novelty response or the familiarity response, the latter consisting in any activity that has formerly been aroused by the object. The whole theory, though far from proved, is of some interest because it makes recall and recognition fundamentally the same process.

MEMORY TRAINING

The important question whether memory can be improved by any form of training breaks up, in the light of our previous analysis, into the four questions, whether memorizing can be improved, whether the power of retention can be improved, whether recall can be improved, and whether recognition can be improved. As to recognition, it is difficult to imagine how to train it; the process is so elusive and so direct. Recall, too, is rather unmanageable, but our previous discussion has brought out at least one point of practical value. The try-rest-try-again attack upon something which eludes recall is a technique that one can adopt with advantage. Trusting your memory, also, is a favorable attitude for recall, much better, certainly, than an anxious doubt whether memory is not going to fail you, and this desirable confident attitude can be strengthened by making it a practice to rely upon your memory.

As to retention, since it is not a performance but a resting state, how could we possibly go to work to improve it? About all that can be suggested is to keep the brain in good physical condition. Retentiveness can be protected by hygienic measures, but not improved, so far as we know, by any form of training.

However, the process of learning or committing to memory, being a straightforward and controllable activity, is exceedingly susceptible to training. The beginner in learning lists of nonsense syllables is emotionally wrought up and uncertain of himself, goes to work in a random way (like any beginner), perhaps tries to learn by pure rote or else attempts to use devices that are ill-adapted to the material, and has a slow and tedious job. With practice in learning this sort of material, he learns some appropriate technique, becomes sure of himself and free from emotional disturbance, and may even enjoy the work. Certainly he improves greatly in speed of memorizing nonsense syllables. If, instead, he practices on Spenser's "Faery Queen," he improves in that, and may cut down his time for memorizing a twelve-line stanza from fifteen minutes to five. This improvement is due to the subject's finding out how to organize this particular sort of material. He gets used to Spenser's style and range of ideas. And so it is with any kind of material; practice brings great improvement in memorizing that particular material.

Whether practice with one sort of material brings skill that can be "transferred," or carried over to a second kind of material, is quite another question. Usually the amount of transfer is small compared with the improvement gained in handling the first material, or compared with the improvement that will result from specific training with the second kind. What skill is transferred consists partly in the habit of looking for groupings and relationships, and partly in the confidence in one's own ability as a memorizer. It is really worth while taking part in a memory experiment, just to know what you can accomplish after a little training. Most persons who complain of poor memory would be convinced by such an experiment that their memory was fundamentally sound. But these laboratory exercises do not pretend to develop any general "power of memory," and the much advertised systems of memory training are no more justified in such a claim. What is developed, in both cases, is skill in memorizing certain kinds of material so as to pass certain forms of memory test.

When anyone complains of a "poor memory" for any special material, as names, errands or engagements, the trouble can usually be found in his heedless way of committing the facts to memory, not in his power of retention. President Seelye of Amherst College, back in the '80s, never failed to call a student or alumnus by name, after he had interviewed the man in the freshman year. In this interview, besides fatherly advice, he asked the man personal questions and studied him intently. He was interested in the man, he formed a clear impression of his personality, and to that personality he carefully attached the name. Undoubtedly this able scholar was possessed of an unusually retentive memory; but his memory for names depended largely on this method.

Contrast with this the casual procedure of most of us on being introduced to a person. Perhaps we scarcely notice the name, and make no effort to attach the name to the personality. To have a good memory for names, one needs to give attention and practice to this specific matter. It is the same with memory for errands; it can be specifically trained. Perhaps the best general hint here is to associate the errand beforehand in your mind with the place where you should remember to do the errand.

Often some little *mnemonic system* will help in remembering disconnected facts, but such devices have only a limited field of application and do not in the least improve the general power of memory. Some speakers, in planning out a speech, locate each successive "point" in a corner of the hall, or in a room of their own house; and when they have finished one point, look into the next corner, or think of the next room, and find the following point there. It would seem that a well-constructed speech should supply its own logical cues so that artificial aids would be superfluous. In training the memory for the significant facts of one's business, the best rule is to interrelate the facts into a system. The cross-connections between the items in the system provide plenty of good cues for the recall of any desired item.

In general, memory-training consists in improved management of the learning process. Observant study, alive to patterns, relationships, meanings, and promising cues for later recall — economy of effort in learning, by use of recitation, spacing, and the best combination of whole and part study to fit the material in hand — these principles of good management indicate the field in which memory can be effectively trained.

REFERENCES

1. Allport, G. W. "Eidetic imagery." *Brit. J. Psychol.*, 1924, 15, 99–120.

2. Boreas, T. "Experimental studies of memory." (Greek) *Praktika l'Acad. Athènes*, 1930, 5.

3. Ebbinghaus, H. *Über das Gedächtnis.* 1885. Memory. Translated by H. A. Ruger & C. E. Bussenius. 1913.

4. Gamble, E. A. M., & Calkins, M. W. "Die reproduzierte Vorstellung beim Wiedererkennen u. beim Vergleichen." *Zt. Psychol.*, 1903, 32, 177–199.

5. Gates, A. I. "Recitation as a factor in memorizing." *Arch. Psychol.*, 1917.

6. Gibson, J. J. "The reproduction of visually perceived forms." *J. Exper. Psychol.*, 1929, 12, 1–39.

7. Hollingworth, H. L. *Psychology: its facts and principles.* 1928. esp. p. 198.

8. Jaensch, E. R. *Eidetic imagery.* 1930.

9. Jost, A. "Die Assoziationsfestigkeit. . . ." *Zt. Psychol.*, 1897, 14, 436–472.

10. Leonard, W. E. *The locomotive God.* 1927.

11. Muhl, A. M. "Automatic writing . . . as a means of recalling forgotten incidents." *J. Abn. Psychol.*, 1924, 19, 264–273.

12. Murphy, G. *An historical introduction to modern psychology.* 1932. H. Klüver, pp. 437–442.

13. Piéron, H. "Recherches expérimentales sur les phénomènes de mémoire." *Année Psychol.*, 1913, 19, 91–193.

14. Pyle, W. H., & Snyder, J. C. "The most economical unit for committing to memory." *J. Educ. Psychol.*, 1911, 2, 133–142.

15. Seward, G. H. "Recognition time as a measure of confidence." *Arch. Psychol.*, 1928.

16. Skaggs, E. B. "Further studies in retroactive inhibition." *Psychol. Monog.*, 1925, 34.

17. Thorndike, E. L. *An experimental study of rewards.* 1933.

18. van Ormer, E. B. "Retention after intervals of sleep and of waking." *Arch. Psychol.*, 1932.

19. Zeigarnik, B. "Das Behalten erledigter u. unerledigter Handlungen." *Psychol. Forsch.*, 1927, 9, 1–85.

20. Hull, C. L. *Hypnosis and Suggestibility.* 1933. A scientific study of the phenomena, preceded by a history of the subject from Mesmer down. The elementary phenomena of muscle reading, waking suggestibility, the trance, rapport, and posthypnotic suggestion and amnesia are presented in the form of demonstrations. There follow a series of experiments indicating that hypnosis is (a) not a form of sleep, (b) not productive of supernormal sensitivity, (c) not neurotic or hysterical, but (d) a state of heightened susceptibility to prestige suggestion, in which it is possible (e) to recover lost memories.

CHAPTER XII

MOTIVATION

A man's achievement may fall far short of his ability because of lack of effort or scattering of effort. He may be indifferent, he may dislike the situation or persons connected with his work, or he may be too much absorbed in some other line of activity to put himself heartily into his work. In all such cases the individual can be said to lack motivation.

For all the practical importance of motives, it does not follow that the concept of motive is fundamental in psychology. The wheel is of immense practical importance in machinery, but is not a fundamental fact for physics. The prehistoric inventor of the wheel introduced nothing so radically new as did the nineteenth-century physicists who invented the dynamo and so brought into machinery the new factor of electricity. Is a motive a dynamo or simply a wheel?

The question is whether the concepts which we have used since the beginning — concepts of stimulus and response, of sets, especially goal-sets, and of activity in progress — are sufficient for the description of motivated activity. Or, the question is whether we have not been surreptitiously assuming all along the existence of an internal driving force radically different from mere activity and from stimulus and response (7).

Motive and stimulus. If my hand touches a hot stove and I jerk it away, there is no excuse for saying that my *motive* was to remove the hand from the hot object. The movement was a direct response to the stimulus and there was no motive present in advance preparing me to make this response. But suppose, the pain in my hand continuing, I catch sight of a pail of water and plunge my hand into it. This is not my usual response to a pail of water, but at that particular moment, besides the visual stimulus from the pail of water, there was an activity in progress, a seeking to escape from the burning pain in my hand. This activity in progress was the motive for my unusual response to the pail of water.

In eating we have a similar case. If we ask what are the stimuli directly arousing the eating movements, we must answer that these stimuli come from the actual food, in the absence of which the eating movements do not occur. If we ask for the motive here, the answer is hunger, or food-seeking. Hunger is primarily a chemical condition of the organism, rather than an activity in progress, but this condition gives rise to vigorous stomach contractions (felt as hunger pangs), in response to which the individual becomes restlessly active and seeks food.

In both cases mentioned, the activity in progress is kept going by a continuing stimulus in or on the individual. But a continuing stimulus cannot be demonstrated in the " delayed reaction " (p. 234) nor even in ordinary maze running, to say nothing of the higher types of human activity. We should not be justified in generalizing to the effect that a motive was a continuing stimulus; but we can say, apparently, that any motive is an activity in progress. We have to assume, or admit, that an activity can be " in progress," i.e., that it can continue and even make progress after the cessation of the particular stimulus which is necessary to start it going.

A whole activity motivates its component part activities. The activity of daily life comes in lengths rather than in separate reactions. You put on your coat and hat; you go out to the garage; you start the car; you back out; you take on your passengers; you drive them to the station. Thus one might list the acts performed in a certain quarter of an hour. You have embarked upon a certain total activity, which immediately becomes your "activity in progress," and motivates all the detailed movements composing the total activity. What you are doing in toto determines what you do piecemeal. If anyone asks you why you are doing this (detail), your answer is, "Because I am doing that (total act)." "Why are you turning the knob?" "Because I'm opening the door." "Why are you opening the door?" "Because I'm going to the garage." "Why are you going to the garage?" "Because I'm taking some people to the station." "And why do that?" "I'm helping them get to their business on time." Each smaller act finds its motive in the more inclusive activity in progress.

In short, there is nothing mysterious about motives. They are not forces or stores of energy in any absolute sense. They are simply activities that have got started but are not yet finished. The significant fact is that activity does occur in large action patterns, more than in single reactions.

ANIMAL DRIVES

In the study of motivation as well as in that of learning there is much to be expected from animal studies, both because conditions can be better controlled in an animal than in a human experiment, and because of the comparative simplicity of the animal. A review of the work on animal learning will show that motivation was almost always employed. The animals were taken when hungry and rewarded for a successful run by food in the food box; they were taken when thirsty and rewarded by water; or they were punished by an electric shock or in other ways. Evidently reward and punishment would be impossible with a creature that had no preferences, no needs, no appetites or aversions. We must take care, however, once more, to avoid anthropomorphism in our concepts and interpretations.

The terms *drive* and *reaction tendency* aim to be purely behavior terms, with no implication of conscious experience or desire in the animal. These two terms are used synonymously or nearly so, though as a word *drive* points back to the internal condition which lies behind an activity, while the word *tendency* points ahead to the goal or reward. But *drive* is not used to mean simply the chemical condition of hunger, for instance; it means the food-seeking character of activity while in this chemical condition, or the food-approaching character of activity when locating food. Concretely, a drive or reaction tendency is an activity in progress.

Measurement of drives. Of several methods used to compare the strength of one drive with that of another, we will mention the *obstruction method,* which offers the animal a reward or incentive but places an obstruction in the way to the goal. A convenient obstruction consists of an electrified grill in the floor of a tunnel through which the animal must pass in order to reach the incentive. The shocks are strong enough to make the animal avoid the tunnel unless there is some incentive present on the far side. After crossing the animal is allowed only a little nibble of food, or a correspondingly small portion of whatever reward is offered, and then is placed back at the entrance. He is given a total of twenty minutes, and the question is how many times he will cross the grill to the incentive. To acquaint the animal with the situation he is first given four trials without the current, followed by a single trial with the current; and then the twenty-minute test period is begun and the animal's crossings counted. Many precautions are of course necessary in order to secure reliable results.

With white rats as subjects, there are about 3 or 4 crossings in twenty minutes with no particular incentive. When the rats are hungry and food is the incentive, the number of crossings is about 18, on the average, after a fast of two, three or four days, but after still longer periods of fasting the number of crossings declines. We may accept 18 crossings in the twenty-minute test period, then, as the maximum effect of the hunger drive (for the average standard white rat of a definite age). In the same way the maximum is determined for thirst, for the sex drive in the male and in the female, and for the maternal drive. In the last case a mother is taken from her litter and has to cross the grill to rejoin them; a mother that has borne her young within the day makes a higher score than one whose litter is a week old, indicating that the maternal drive falls off in the rat rather quickly after parturition.

The results on the sex drive have already been reported in connection with the topic of sex hormones (see p. 120).

In comparing the different drives, we should take each at its maximum. The results, expressed in number of crossings of the grill within the twenty-minute test period, are as follows (8):

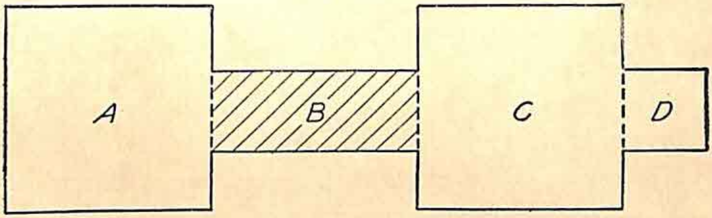


FIG. 66. — Ground plan of an obstruction box. (After Warden, 8.) The animal is placed in compartment A and has to cross through the tunnel B (which for rats is 4 inches wide and 4 inches high) and take electric shocks from the wires in the floor, in order to reach C and D. The incentive is in D, but is automatically released (when it is an animal, as a female incentive in testing the male sex drive) as soon as the subject enters C.

Drive tested	*Average no. crossings*
Maternal	22.4
Thirst	20.4
Hunger	18.2
Sex	13.8
Exploratory	6.0
No incentive	3.5

Small differences in these averages are not well established, but there seems no doubt that the maternal, thirst and hunger drives, at their respective maxima, are more insistent than the sex drive at its maximum, and that the sex drive in turn is stronger than the exploratory. With regard to the last point, however, the animal psychologists report that the rat foregoes either food or sex activity in any strange locality until he has first explored the place. There seems no possible doubt of the genuineness of the exploratory tendency, at least in the white rat.

There is good evidence also of an activity drive, a drive for motor activity. For if a rat is kept in a cage provided with a running wheel, as in a squirrel cage, he spends a good share of the time running in the wheel, instead of sitting still in the rather contracted stationary part of the cage, and when a counter is attached to the wheel, it often records the equivalent of five, ten or even twenty miles in the course of twenty-four hours (5).

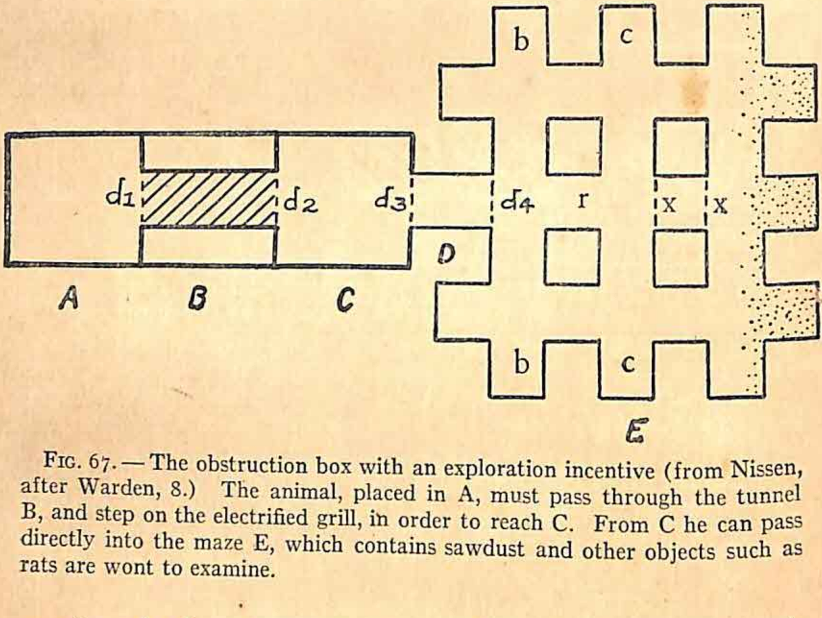


Fig. 67. — The obstruction box with an exploration incentive (from Nissen, after Warden, 8.) The animal, placed in A, must pass through the tunnel B, and step on the electrified grill, in order to reach C. From C he can pass directly into the maze E, which contains sawdust and other objects such as rats are wont to examine.

If we admit an activity drive, we must certainly add the rest and sleep drive, and in this case we need have no hesitation in extending the conclusion to the human species.

UNLEARNED MOTIVES — FORMERLY CALLED INSTINCTS

If we could identify certain motives as dependent only on the maturation of the individual and not on his particular experience and training, such unlearned motives would be of great interest. They would be dependable for practical purposes. They would be widespread if not universal among men and some of them would doubtless be common to men and animals.

According to the conception of motive as an activity in progress, an unlearned motive implies an unlearned activity. We came to the conclusion (p. 223) that wholly unlearned activities were very rare in human beings, and that wholly learned activities could not exist. Are we forced to conclude that no distinction can be drawn between learned and unlearned motives? An activity, such as eating, might have an unlearned trend, direction or aim, and the development of this activity through learning might not alter its general trend. It might continue to start from the same condition, as hunger, and terminate in the same condition, as satiety, though the path followed from the start to the finish were modified by learning. When the trend of an activity in progress is an unlearned trend, it is equivalent to an unlearned motive. The hunger motive or feeding motive can be classified as unlearned, no matter how much refinement the individual may have acquired in his table manners and food preferences.

Instinct. Unlearned trends were formerly called instincts, but the use of this particular term led to confusion, because an instinct was (and is) defined as an unlearned activity. In various forms of animals, especially in insects, beautiful examples can be found of complex action patterns which certainly have never been learned by the individual. The female wasp of a given species constructs a certain type of nest in which to lay an egg, and this specific type of nest is handed down from generation to generation. But it is not transmitted by teaching and learning, for each generation dies before the succeeding generation is hatched from the egg. In man, however, few action patterns occur that are comparable to the typical instincts in being both complex and unlearned.

If we use the word, instinct, in speaking of human activities, we immediately become involved in controversies which are mainly disputes over words. We probably contrast instinct with habit, using the former for an unlearned activity, and the latter for a learned activity. But then, since every activity is partly unlearned and partly learned, we can draw no sharp line between instinct and habit, and are always quarreling over the proper name for a given activity, though there is no real question as to the facts. If we call eating an instinct, someone objects that we are overlooking all the learning that occurs in ways of preparing food and putting it into the mouth, and all the social customs that have grown up around eating. But if we call eating a habit, we are accused of taking the absurd position that man eats only by force of habit and not because he is hungry and has the unlearned trend for satisfying this organic need. If we speak of the sex instinct, someone is sure to carry away the impression that romance, courtship and marriage, as practiced among men, are unlearned activities on a par with the nest-building of wasps; but if we speak of sex behavior as a habit, we convey the impression that the attraction of one sex for the other is a mere matter of social convention. On the whole, we shall save trouble by minimizing the use of both terms, instinct and habit, and leaving both to be terms of popular rather than of scientific use.

But no such confusion need arise from speaking of the unlearned trend of certain activities, or from speaking of unlearned motives in this sense. The genetic study of motives will have to be much farther advanced than at present, however, before a complete list of unlearned motives can be laid down.

Organic needs. Each need is primarily a chemical or physical condition of the organism. Hunger is a depletion of the food materials within the body, thirst a depletion of water, asphyxia is an extreme degree of the depletion of oxygen and accumulation of carbon dioxide that activate breathing. Fatigue is an accumulation of the waste products of muscular activity, and drowsiness or sleep-hunger may be akin to fatigue.

Each of these organic needs motivates a whole system of learned activity. We might speak of hunger behavior, thirst behavior, breathing behavior, rest behavior, sleep behavior, as systems of activity developed from these several trends. In the social life of man, each of these systems of activity becomes very extensive. Think of all the activities connected with food: hunting, agriculture, cooking, eating places, table manners, social festivities, the science of nutrition.

The individual, though so plastic and apt in learning, is no mere learner, no mere clay to be molded by social pressure. The organic needs are so many demands which the individual makes upon the environment, and since every individual makes these demands, society is compelled to meet them, and social customs, while molding the individual, must at the same time satisfy the individual.

The sex motive. Mention has already been made of the sex hormones (p. 120) and of the estrous cycle in the female, with its resulting periodicity of the sex drive in the white rat at least, and also of the increase of the sex drive in the male for a time after sex activity. There is thus revealed an unlearned organic basis for sex activity. In the rat the overt mating behavior also is found to be unlearned (6). In man, the organic factors are much the same as in animals, so that there is undoubtedly an unlearned trend in sex behavior. Human courtship must be largely learned behavior, it differs so widely from one social group to another; and yet there is a subtle difference between the young man and the young woman, in their behavior towards each other, which seems to run through all cultures, and which contributes to the attractiveness of each sex for the other.

The maternal motive or mother love. In many kinds of animals, though not by any means in all, one of the parents stays by the young till some degree of maturity is reached. In some fishes, it is the male that cares for the young; in birds it is often both parents. In mammals it is always the mother. A hormone plays a part here, as is seen from the spontaneous appearance of the mother's milk with the birth of the young. This hormone is present in the human mother too, and puts her into a special organic state. There is good reason to believe that the hormone has an effect on her feelings and mode of behavior. No doubt most of the details of child care are learned by the mother, but certain elementary desires do not have to be learned — to cuddle and feed the baby, to seek to stop its crying, to fight off anyone who threatens it.

The escape motive — shrinking from injury — fear. The flexion reflex of the arm or leg, which pulls it away from a pinch, prick or burn, is one of a host of simple avoiding reactions — winking, scratching, coughing, sneezing, clearing the throat, wincing, limping, squirming, changing from an uncomfortable position — most or all of them unlearned reactions. Often a peculiar organic state is set up in the trend to escape from pain or injury, the hormone of the adrenal glands being poured copiously into the blood stream, with the result that the organism is thrown into a keyed-up, excited condition. This is the condition sometimes labelled the "emotion of fear," which we will examine more closely in the following chapter.

The little baby fears nothing, or almost nothing. He makes avoiding reactions to stimuli that are directly irritating, but not to stimuli that are simply signs of danger. The fears of older people do not appear in the baby. For example, he is not afraid of a furry animal, or of a snake.

If the snake test (a large but harmless snake, carried around by the experimenter, who invites everyone to feel his nice smooth, hard skin) is tried on people of different ages, no child under two years shows any fear or concern; at three or four they begin to be somewhat wary, and within the next few years some of them show definite avoidance, both boys and girls. College students show more fear than boys and girls of ten or younger (3).

How shall this increase of fears with age be explained? From the experiment on conditioned fears, in which the fear of a furry animal was built up in a baby by sounding the rasping noise whenever the baby reached for the attractive animal, we see how some fears are acquired. A child may be afraid of dogs because he has been bitten by one. More often he becomes afraid from being warned by older people or from observing their fear responses. Thus children who are originally not the least bit afraid of thunder and lightning may pick up a fear of them from adults who show fear during a thunderstorm.

But just as development is partly maturation and not entirely learning, so the increase of the child's fears with age is not entirely due to such accidental "conditionings." Part of the increase is due to the child's growing up. At first he cannot be frightened by way of his eyes, but as he comes to see better, he is startled by sudden movements such as the jump of a frog or of a jack-in-the-box. At first he understands little of what is going on around him, but as he understands more and participates more, he finds more need for caution.

In later childhood, adolescence, and early adult life, many fears are outgrown, overcome, or more or less completely suppressed. The suppression may do away with the external signs of fear without wholly removing the internal organic state. So, an adult who handles the snake with apparent calm may show beads of perspiration on his forehead; and a person who can stand on the brink of a precipice without panic may yet feel much more at ease when he has retired. Nevertheless, such fears are often really overcome and left behind.

Fighting — anger. Angry behavior as seen in a child of one or two years is a surprising phenomenon. Prevented from doing what he wishes or forced to do something he does not wish, the child is likely to burst out into undirected motor activity, jumping up and down and screaming; or he may struggle against the interfering person or object; or again he may attack that person or object. This outburst may last for a longer or shorter time, but typically for 1–5 minutes. Such behavior is far from dependable even in the young child and it becomes less frequent as he grows up under civilized conditions (2). In anger as in fear, a large part of the activity is internal and organic, and this part often persists, no doubt, even when the individual has learned to suppress his external pugnacious behavior, or when he has substituted angry talk for the primitive struggling, kicking and screaming.

Pugnacious individuals, dogs or men, seem to derive more solid satisfaction from a good fight than from any other amusement. A good fighting dog will sally forth in search of an opponent. A person will "pick a quarrel" by provoking some one who is minding his own business. We must recognize aggressive fighting, then, as well as defensive, and both sorts are important in social situations.

Exploration. Up to this point in our list of unlearned motives, we have been able to point to some organic condition playing an important part in each motivating activity, and being itself almost certainly unlearned. There are several other activities and motives for which no organic basis is known, so that our evidence for an unlearned trend is weaker in these cases. In the case of exploratory activity we have found evidence that it is a genuine drive in the white rat at least. The "trend" is towards acquaintance with a locality.

Manipulation. It is characteristic of the human being to explore not only places but objects, and to do so by watching the objects while manipulating them. There must be a natural human propensity for this sort of activity, so early and so spontaneously does it appear in the child's play. As soon as the child can handle external objects, he begins to manipulate them in various ways, which become more complex and efficient as his powers increase. Manipulation and exploration are practically a single activity in the child's play. If any object awakens his curiosity he is not satisfied to look at it but tries to get it into his hands. He makes the object perform and so learns how things behave in the world. This observant manipulatory play is of immense importance in the development of knowledge and skill.

Social motives. Man is so much a social animal that even such an organic need as hunger gives rise to social behavior. Fear and especially anger are oftenest aroused by other people. Sex behavior brings people together in pairs, and maternal behavior gives us homes and families. Thus many motives become socialized. The question remains whether there is any primary social motive. The herd instinct, or gregarious instinct, is often spoken of as such a motive. Man belongs with the more gregarious animals, like the deer and the wolf, rather than with the so-called solitary animals like the lion. But it is very difficult to decide whether man's preference for living, working and playing in groups is learned or unlearned. From his prolonged period of dependence, the human child is bound to be "conditioned" to group life, even if he were naturally indifferent to it. Learned or unlearned, the social motive is strong and dependable. It is a love not simply for company, but for participation in the activity of the group.

The mastery or self-assertive motive. Now we come to a motive for which we can point out no specific kind of activity, since it is a motive that can be found in many kinds of behavior. It appears in the more aggressive form of striving to command, to lead, to dominate the situation, to master and manage an object, and in the more defensive form of resistance to domination and dislike of defeat. Some persons who are not specially eager to dominate nevertheless hate to be dominated.

Though the activities in which this motive appears are so various, they all have a common trend — from inferiority to superiority, from defeat to victory, from a state of being thwarted to a state of mastery.

The mastery motive cannot be wholly a learned affair. Practically all the "conditioning" that the child gets would tend towards making him submissive and not masterful. He starts as a little, dependent creature, surrounded by big creatures who do everything for him and expect him to yield and obey. But the child shows from an early age that he has a will of his own and wants his own way in opposition to the commands of other people. He shows the aggressive as well as the defensive type of masterfulness. Even the baby gives orders and demands obedience. He discovers other, less direct ways of dominating other people as he grows older. Showing off is one way, bragging is one, doing all the talking is one; and, though in growing older and mixing with people the child becomes less naïve in his manner of bragging and showing off, he continues even as an adult to seek applause and social recognition. Anything in which one can surpass another becomes a means of self-assertion.

Rivalry and *emulation*, sometimes accorded a separate place in the list of motives, seem well enough provided for under the general head of self-assertion. They belong on the social side of assertive behavior, i.e., they are responses to other people and aim at the domination of other people or against being dominated by them.

Thwarted self-assertion deserves special mention, as the basis for quite a number of queer emotional states. Shame, sulkiness, sullenness, peevishness, stubbornness, defiance, all go with wounded self-assertion under different conditions. Envy and jealousy belong here, too. Shyness and embarrassment go with self-assertion that is doubtful of winning recognition. Opposed to all these are self-confidence, the cheerful state of mind of one who seeks to master some person or thing and fully expects to do so, and elation, the joyful state of one who has mastered.

Masterful behavior is directed not only towards other people, but also towards all sorts of things that can be managed. If the child has a horn, he is not satisfied till he can sound it himself. The man with his automobile is in the same case. When it balks, he is stimulated to overcome it; but when it runs smoothly for him, he has a sense of mastery and power that is highly gratifying. Chopping down a big tree, or moving a big rock with a crowbar, affords the same kind of gratification; and so does cutting with a sharp knife, or shooting with a good bow or gun, or operating any tool or machine that increases one's power. Quite apart from the utility of the result accomplished, any big achievement is a source of satisfaction to the one who has done it, because it gives play to aggressive self-assertion.

Likes and dislikes. Besides the motives which are "trends of activity," there are learned and unlearned tastes, or likes and dislikes, that seem rather passive and independent of any activity in which the individual may be engaged. Sweet is liked and bitter disliked, just for themselves. Certain odors are liked and others disliked. Bright colors are liked; smooth tones are liked, simple rhythms are liked. These likes and dislikes do not have to be learned, whereas the liking for lemonade, coffee, olives or cheese has to be acquired by learning, as is true also of the liking for subdued colors or for close musical harmonies.

Such likes and dislikes are motivating factors in the development of the arts. The culinary art could not have developed in the absence of pleasant tastes, nor the perfumer's art in the absence of pleasant odors. The color art is certainly dependent on human love of color, and music on love for tones and rhythm. Once these arts are in existence, the artists find opportunity in them for the mastering of technique, and for self-display and social prestige. But surely the arts are not accounted for by the self-assertion of the artists. The artists themselves would not go far without a love for the tones and colors and other elements of their arts.

Unlearned motives are not the only springs of action. Now that we have assembled an impressive list of unlearned motives, it may seem logical to assert that they are the mainsprings of all human activity. Such statements have in fact been made. Sometimes the list of primary motives has corresponded rather closely to our list above, sometimes it has been more extensive. Sometimes hunger, sex, fear and anger have been singled out as the only fundamental motives.

Your author's contention is that any such system is radically wrong. These few motives are not like so many mainsprings of a complicated clock, one or another of which must be driving the works at any time. They may all be inactive at a given moment, and still the individual may be active. He may not be hungry or thirsty or angry or afraid or sexually eager, and yet he may be busily engaged in some activity. Provided he has got well started in some activity, he has a zest for carrying it through. A motive, we said, was an activity in progress, and any activity in progress may be a motive for the time being. If a person has started to solve a puzzle, his motive for the time is to solve that particular puzzle.

The motivation of any extensive activity is likely to be very complex. The "economic motive," for example, cannot be identified with the hunger motive alone, for the working individual need not be hungry and need have no driving fear of starvation. It cannot be identical with the sex motive, for he works when not sexually excited, and his plans for marriage may be too vague to drive him to work. The exploring motive undoubtedly plays a part while he is becoming acquainted with a new occupation, and the mastery motive when he faces the difficulties of his work, or when he is in danger of being outclassed by his fellows. But if his job suits him, he finds the actual operations interesting; and on any particular day he has a definite goal to reach and becomes absorbed in the particular activity leading to that goal.

CONFLICT OF MOTIVES

The individual is complex, with many different activities that can be aroused. The environment is complex, affording stimuli for various activities. Conflict, then, is sure to arise, and a selection must be made between inconsistent activities.

The state of indecision. When a conflict arises, the first result is a state of indecision, this "state" being really a complex activity, often very intense and often very confused. It works itself out, somehow, into the state of being committed to one of the alternative lines of action.

The state of indecision may amount simply to *hesitancy*, when the conflict is between doing something, on the positive side, and fear, shyness or inertia on the negative side. Hesitancy is apt to occur before getting out of bed in the morning, before taking a plunge into cold water, or before speaking out in meeting or in a general conversation. To get action, the positive motive must be stronger than the negative, at least for an instant.

Vacillation is a more complex state of indecision, when the choice lies between two desirable goals, or between two evils. Vacillation is certainly unpleasant. We want action, or else we want peace, but vacillation gives us neither. In spite of its irksomeness, we seem sometimes almost powerless to end it, because as soon as we have about decided on the one alternative, what we shall miss by not choosing the other comes vividly to mind, and swings the pendulum its way.

However, a decision is usually reached, and then it usually sticks. A student may vacillate long between the apparently equal attractions of two colleges, but when he finally decides on one, the advantages of the other lose their hold on him. Now he is all for one and not at all for the other. Some people, indeed, are abnormally subject to vacillation and never accept their own decisions as final, but normally a decision, once reached, is fortified by the satisfaction of having a definite course of action and by self-assertion, because *we* have decided, and now this course of action is *ours*.

The process of decision. While the state of indecision and the final state of decision are very different, the process of passing from one to the other is often difficult to trace. There is a sort of mental exploration of the alternatives, but the process differs from one case to another.

Deliberation. Sometimes each alternative is pictured as well as possible, and weighed against the other. This is ideally rational, but often impracticable, for lack of knowledge of how each line of action would turn out. Even if practicable, deliberation may be too irksome to pursue to the bitter end. Perhaps the most common process is a sort of partial deliberation, the two alternatives appealing to us by turns till at some moment one of them makes so strong an appeal as to secure the decision.

Incubation of a decision. When a deadlock arises between alternative courses of action, the most rational procedure is usually the same that was found useful in the recall of a forgotten name or in the solution of a difficult problem (p. 283): to let the matter rest for a time, and perhaps sleep over it — after which we may find that one alternative has lost its momentary attractiveness and the other holds the field.

Arbitrary decision. Sometimes a deadlock is so irritating and humiliating, almost, that we say, "Any decision is better than none; here goes, then; *this* is what I will do," so breaking the deadlock by what seems to be a mere toss-up.

Does the decision always follow the stronger motive? Logically it would seem that the stronger motive must prevail. But motives have a way of bringing in allies, and then the question becomes, which *team* of motives is the stronger. A primitive craving, pitted against self-denial, would have the advantage, except that self-respect and loyalty to another individual or to one's social group may line up on the side of the weaker motive and give it the decision.

What becomes of the rejected motives? If you ask a person who has just fought his way through from a state of indecision to a state of decision to reopen the question and consider whether the rejected alternative might not be better, he is very unwilling to go back into the fight and turmoil of indecision; and if he does reopen the question, he usually finds the rejected alternative wholly lacking in pulling power. The process of decision has deadened the rejected motive. Thus the rejected motives may simply *lapse* into an inactive state and be gradually forgotten.

A deeply rooted motive, which cannot be so easily eliminated, may often be quieted by *deferring* it, by assuring it that its turn will come later on. Sometimes it is *disguised* and then gratified, as when an outwardly courteous action contains an element of spite. Sometimes it is *sublimated* or granted a substitute gratification, as when the boastful boy, after having the conceit taken out of him by his fellows, boasts no longer of himself but of his school, town or country. Sometimes it is tricked by *defense mechanisms*, such as the "sour grapes" mechanism, a pretending that we don't want what we can't reach or what we have decided not to touch.

Some motives are *repressed* in the sense emphasized by the psychoanalysts. A strong desire is made unconscious, while still remaining in the system and finding gratification in dreams and in major or minor disturbances of waking life. Sometimes the desire for a particular thing is replaced by a senseless fear of that same thing. Repression grows out of an unresolved conflict (p. 282).

The most adequate way of handling rejected motives is to *coördinate* them with accepted motives — to harness them into teams and set them to work. This cannot always be done; for example, if a young woman has two attractive suitors, she may find difficulty in harnessing them together. But when the boastful boy becomes a loyal and enthusiastic member of a school, his self-assertive motive is combined with social motives into an effective team. Probably a motive can be sublimated only by combining it with other motives.

These various ways of handling a rejected motive can be illustrated in the case of the sex motive. It so happens, partly because modern economic and educational conditions enforce a delay in marriage — and in part simply because there are so many attractive people in the world — that the cravings of sex must often be denied. What becomes of them? Of course the sex motive is too deep-seated to be eradicated. But the fascination for particular individuals may lapse and be forgotten. Certain people we remember, once in a while, with half-humorous and certainly not very poignant regret. Deferring the whole matter till the time is ripe works well with many a youth or maiden. Combined with social interests, the sex motive finds sublimated satisfaction in a great variety of amusements, as well as in business associations between the sexes. Introduce a nice young lady into an officeful of men, and the atmosphere changes — which means, certainly, that the sex motive of these men, combined with ordinary business motives, is finding a sublimated satisfaction. The sex motive thus enters into a great variety of human affairs. Defense mechanisms are common in combating erotic impulses; the sour grapes mechanism sometimes takes the extreme form of a hatred of the other sex; but a very good and useful device of this general sort is to throw oneself into some quite different type of activity, as the young man may successfully work off his steam in athletics. This is not sublimation in any proper use of that term, for athletic sport does not gratify the sex tendency in the least, but it gratifies other tendencies and so gratifies the individual. It is the individual that must be satisfied, rather than any specified one of his tendencies. As regards coordination, the fact was illustrated just above that this method would not always work; but sometimes it works immensely well. Here is a young person (either sex), in the twenties, with insistent sex impulses, tempted to yield to the fascination of some mediocre representative of the other sex. Such a low-level attachment, however, militates against self-respect, work, ambition, social sense. Where is the coordination? It has to be found; some worthy mate will harness all these tendencies, stimulating and gratifying sex attraction, self-respect, ambition and others besides, and coordinating them all into the high-grade sentiment of love.

UNCONSCIOUS MOTIVES

Schopenhauer wrote much of the "will to live," which was, in his view, as unconscious as it was fundamental, and only secondarily gave rise to the conscious life of sensations and ideas. Bergson's "élan vital" has much the same meaning. In a sense, the will to live is the fountain of all our wishes; in another sense, it is the sum total of them all; and in another sense, it is an abstraction, the concrete facts consisting in the various particular wishes and tendencies of living creatures. The will to live is not simply the will to stay alive; it is the will to *live*, with all that that includes. Life is activity, and to live means, for any species, to engage in the full activity possible for that species.

The will to live is in a sense unconscious, since it is seldom present simply in that bald, abstract form. But since life is activity, any will to act is a special case of the will to live, so that the will to live is always conscious whenever there is any conscious impulse or purpose.

In this simple statement we may find the key to all unconscious motives. If you analyze your motive for doing a certain act and formulate it in good set terms, then you have to admit that this motive was unconscious before, or only dimly conscious, since it was not formulated, it was not isolated, it was not present in the precise form you have now given it. Yet it was there, bound up in the total activity. It was not unconscious in the sense of being active in a different, unconscious realm. The realm in which it was active was that of conscious activity, and it formed an unanalyzed part of that activity.

In the same way, we do not realize in helping a friend that we are at the same time dominating over him, but think, so far as we stop to think, that our motive is pure helpfulness. Later, analyzing our motives, we may separate out a masterful tendency, which was present all the time and consciously present, but so bound up with the other motive of helpfulness that it did not attract our attention. Now if our psychology makes us cynics, and leads us to ascribe the whole motivation of the helpful act to the mastery impulse, and therefore to regard this as working in the unconscious, we are fully as far from the truth as when we uncritically assumed that helpfulness was the only motive operating.

For man, to live means a vast range of activity — more than can possibly be performed by any single individual. We wish to do a thousand things that we never can do. Physical incapacity, mental incapacity, limitations of our environment, conflict between one wish and another of our own, opposition from other people and mere lack of time compel us to give up many of our wishes. Renunciation is the order of the day, from childhood up to the age when weakness and weariness supervene upon the zest for action, and the will to live fades out into readiness to die.

Freud's conception of the unconscious. Freud's system is much too elaborate to be set forth here with any approach to completeness. Besides primitive trends which have never emerged into consciousness, Freud regards any wish as unconscious when it has been violently repressed and when the individual resists any attempt to revive it consciously. Along with wishes the experiences are repressed in which those wishes were once active. The sex wishes of childhood, Freud believes, were very genuine and insistent and are still alive and unconscious, and along with them are spite wishes which were originally tied up with the sex wishes. They are not dead, but very much alive in their unconscious state. They emerge in disguise in the dreams of the night, and sometimes interfere with the conscious activities of the day. They motivate our queer and apparently accidental acts, such as slips of the tongue and other mistakes, and the much more serious neurotic symptoms that appear in some individuals. They even motivate, by sublimation, a large share of our serious endeavor in life. All the great springs of action are sought by Freud in the unconscious (1).

The whole system appears to rest on shaky foundations and not to harmonize well with the better-established parts of psychology. The concept of the unconscious, in general, is a handicap if it leads us to think of the individual's activity as composed of two distinct parts, the conscious and the unconscious. The concept may be of value if it leads us to remember that the roots of present behavior extend far back into the individual's past, and that long-forgotten experiences, conflicts and adjustments still have their effects in the present.

EFFORT

An activity may be blocked or impeded not only by a conflicting motive of the same individual but also by the opposition of other persons or by something in the physical environment.

When an activity encounters an external obstacle, there are two ways in which the individual can respond, by yielding or by effort to overcome the obstruction. The effort response is more common and more in line with the fundamental characteristic of the organism, mentioned in the opening chapter. The individual, we said, maintains a relative independence by resisting the forces of the environment. Instances of resistance can be found at the reflex level of activity. Take the baby's foot and move it this way or that, and you will find that the leg muscles are resisting this extraneous movement. Obstruct a movement that the baby is making, and additional force is put into the movement, overcoming the obstruction. These are natural or unconditioned reflexes.

A more complex reflex of the same sort is the movement of straining: a full breath is taken, the glottis is closed preventing the escape of air from the lungs, and then a strong movement of expiration is made. The most obvious result of this peculiar movement is to produce pressure in the abdomen and so assist in the evacuation of the bladder or rectum; and that is the way the baby first uses it. But it also sets the chest and stiffens the whole trunk for lifting a heavy weight or for any great muscular strain, and it regularly enters into any such muscular effort. It is the typical reflex of effort, a natural reflex that becomes attached to all sorts of effortful reactions, and conditioned to all sorts of difficult situations. Careful observation will show that it occurs dozens of times a day, even where the effort required is more mental than muscular.

There are many other movements of effort: gritting the teeth, clenching the fist, stiffening the neck, frowning in the effort to see better, leaning forward for the same purpose, even when, as at a football game, getting a foot or two nearer the show cannot make any noticeable difference to the eyes. Ask a child just learning to write why he grasps the pencil so tightly, why he bends so closely over the desk, why he purses his lips, knits his brow and twists his foot around the leg of the chair, and he might answer, very truly, that it is because he is *trying hard*. All this muscular effort shows the release of extra energy by the difficulty encountered.

A weight-lifting experiment. A weight was suspended from a cord that passed over a pulley and ended in a handle. The subject grasped the handle and lifted the weight by flexion of the arm, the biceps being the chief muscle used. He was told to lift the weight with his utmost force, and meant to do so. Yet, when the experimenter increased the weight, the subject increased his force; and when the experimenter decreased the weight, the subject involuntarily decreased his force. The subject kept the speed of his movement fairly constant, as if following his own standard as to how rapid the movement should be, and varied his muscular force to match the weight encountered. The same result was obtained from all the individuals tested. The greater the obstruction encountered, then, the greater is the output of muscular energy.

A distraction experiment. A subject is isolated in a quiet room, and starts a difficult typewriting job. Suitable apparatus records the speed and accuracy of his work, and also his breathing and the force with which he strikes the keys. He is told to work as rapidly as possible. After he has worked for a time in quiet, suddenly loud bells and buzzers begin to sound, one after another, from all parts of the room. He is disturbed at first, but soon realizes that the experimenter in the adjoining room is switching on all this noise as a test. Consequently the subject makes an extra effort and usually overcomes the distraction so successfully as actually to increase his speed, with no loss of accuracy. How did the subject overcome the distraction? The pressure record shows that he pounded the keys harder during the noisy period; and the breathing record shows that he tended to speak the letters. He overcame the distraction, then, by throwing more energy into his performance (4).

Any experiment on learning a new performance shows effort to overcome the difficulty of the unaccustomed task. When the beginner has passed the first cautious, exploratory stage of learning, he begins to "put on steam." He pounds the typewriter, if that is what he is learning, spells the words aloud, and in other ways betrays the great effort he is making. Once he has mastered the difficulties of the performance, he reaches a free-running stage in which great effort is no longer required, unless it be for making a record. With reference to effort, then, we may distinguish three stages of practice: the initial, exploratory stage, the awkward and effortful stage, and the skilled and free-running stage.

As a general proposition, and one of the most general propositions under the head of motivation, we can state that obstruction encountered in carrying out any activity stimulates the individual to put more energy into the activity.

PURPOSIVE ACTIVITY

From the very beginning we have assumed goal-seeking and "goal-set" as present in much human and animal activity, though not necessarily in all, and our assumption has been abundantly justified by the facts, as for instance by the delayed reaction, by orientation in the maze and by trial and error behavior.

Though the word "purpose" is sometimes used so broadly as to cover any activity directed to a definite end — any form of goal-seeking — it is better reserved for cases where the individual has some *foresight* of the end. It would be anthropomorphic to assume foresight in an animal running towards a goal which was not in actual sight, and we do better to use such a term as "goal-set," defined so as to make no assumption as to the presence or absence of conscious anticipation. But in human beings there is no doubt of the reality of activities directed towards a foreseen or fore-thought result. Foresight depends on memory, for the outcome of an act cannot be foreseen except by one who has had experience in performing similar acts and noting their results.

Prepared action. A good illustration of a relatively simple type of purposive activity is afforded by the following familiar laboratory experiment on human subjects.

The reaction time experiment. The object is to see how long it takes an individual to respond to a stimulus, or how much time elapses between stimulus and response. The experimenter tells his subject to be ready to make a certain movement as promptly as possible on receiving a certain stimulus. The response prescribed is usually a movement of the forefinger, and the stimulus may be a sound, a flash of light, a touch on the skin. The subject knows in advance exactly what stimulus is to be given and what response he has to make, and is given a "Ready!" signal a few seconds before the stimulus. With so simple a performance, the reaction time is very short, and delicate apparatus must be employed to measure it. The chronoscope used to measure the reaction time reads to the hundredth or thousandth of a second, and the time is found to be about .15 sec. in responding to sound or touch, about .18 sec. in responding to light.

What we have been describing is known as the "simple reaction," in distinction from other experiments that demand more of the subject. In the "choice reaction," there are two stimuli and the subject may be required to react to the one with the right hand and to the other with the left; for example, if a red light appears he must respond with the right hand, but if a green light appears, with the left. Here he cannot allow himself to become keyed up to as high a pitch as in the simple reaction, for if he does he will make many false reactions. Therefore, the choice reaction time is longer than the simple reaction time — about a tenth of a second longer.

The "associative reaction" time is longer still. Here the subject must name any color that is shown, or read any letter that is shown, or respond to the sight of any number by calling out the next larger number, or respond to any suitable word by naming its opposite, etc. He cannot be so well prepared as for the simple or choice reaction, and his reaction time is about a tenth of a second longer, at the very best, than in the choice reaction.

These laboratory experiments can be paralleled by many everyday performances. The runner starting at the pistol shot, after the preparatory "Ready! Set!", and the motorman applying the brakes at the expected sound of the bell, are making "simple" reactions. The boxer, dodging to the right or the left according to the blow aimed at him by his adversary, is making choice reactions, and this type is very common in all kinds of steering, handling tools and managing machinery. Reading words, adding numbers and a large share of simple mental performances are essentially associative reactions.

The simple reaction is obviously an S — R affair, much like the reflex. But the linkage between S and R is only temporary in the simple reaction. The subject in a reaction time experiment would not make that finger move in response to that stimulus unless he had made ready to do so. In order to predict the R from the S, we should need to know that O was prepared to do just this thing. The simple reaction typifies a host of activities that are not specially attached to any stimulus, but which the individual can temporarily attach to a certain stimulus by suitable preparation.

The preparatory set or adjustment. The runner on the mark, set for a quick start, is a perfect picture of prepared-ness. Here the onlookers can see the preparation, since the ready signal has aroused visible muscular response in the shape of a crouching position. But if the onlookers imagine themselves to be seeing the *whole* preparation — if they suppose the preparation to be simply an affair of the visible parts of the body — they forget that the muscles are held in action by the nerve centers, and would relax instantly if the nerve centers should stop acting. The preparation is neural more than muscular. The neural apparatus is set to respond to the pistol shot by strong discharge into the leg muscles.

The preparatory set for an act consists in going as far as possible towards the execution of the act, without actually releasing it. In a false start, or premature reaction, such as often occurs on the running track, preparation has gone a little too far, and released the reaction before the stimulus has arrived.

To adapt our S — O — R formula to prepared reactions, we have to remember that there are two reactions in series here. First, the preliminary signal, P, arouses a readiness to make a certain response; and then comes the stimulus, S, and releases that response. Since the preparation consists in making a start towards R, we may let little r stand for this preparation or set. Then we have

1. Preparation: P — O-r
2. Execution: S — (O-r) — R

The compound symbol, (O-r), denotes O in the state of readiness to make R. S finds O in this prepared state, with the activity R already in progress, but suspended, and gives O the necessary nudge to release the complete R. The symbol (O-r) may also be read, " O set for the response R."

Preparatory reactions. In the experiments just cited, there is nothing for O to do during the preparatory period except to get ready and wait. But in many other cases there are steps to take, means to adopt, in order to reach the intended result. The advance signal arouses not merely a preparatory set, but a series of preparatory responses. When the series has been well trained it becomes a smooth action pattern, like those noticed in maze running and in typing a word as a unit.

Special characteristics of purposive activity. 1. *Precision of adjustment*. Conscious purpose, as we know it from human testimony, is often extremely precise. Your friend starts up and says, "I'm going over to the book store to get a little pocket memorandum book," and you know that he is set to do just that thing. A large share of human behavior is directed to precise ends, often formulated beforehand in words, sometimes in mental images, sometimes in drawings, designs and models of various kinds.

2. *Novelty of adjustment*. An activity that has been repeated many times in the same way becomes nearly automatic. But when a new action pattern must be organized, conscious anticipation comes in very keenly. A beginner in the reaction time experiment anticipates the stimulus to which he is to respond, or the movement that he is to make, as vividly as possible. That is his way of getting up an effective set. As the experiment proceeds, and he becomes accustomed to the task, his anticipation reduces to a general feeling of readiness. Purposive behavior is new behavior, behavior in the making, rather than behavior already organized.

3. *Intensity of adjustment*. As long as a well-practiced action pattern operates smoothly, and always gives the expected result, the expectation may consist in little more than a general feeling that all is well. But if the act meets a snag or runs off the track to give an undesired result, the individual rouses his energies and highly resolves to do the thing right. Thus he tunes up his adjustment.

4. *Breadth of adjustment*. A complex act or series of movements, purposive as a whole, may consist of parts which are non-purposive when considered singly. In signing your name

you have no conscious intention to write each successive letter, but you fully intend to write your name. The higher unit is purposively undertaken, while the component parts run off automatically.

Purpose, according to all that has been said, is not an agency foreign to an activity and directing it from outside, or from above. Purpose is the activity itself, initiated but not completed. It is an activity progressing towards a foreseen goal.

WILL

When we use such a term as " the will," we must be on our guard against this noun. Will is not a thing or machine, but a way of acting. We need a verb or adverb, rather than a noun. To will is to decide between conflicting motives, or it is to overcome obstruction by effort, or it is to enter on a course of action purposely and with anticipation of the goal. The three sections of the present chapter, dealing with conflict of motives, with effort, and with purposive activity, correspond to the appropriate content of a chapter on the will.

Abulia — " no will " — is an abnormal lack of zest for action. Along with it go timidity, proneness to daydreaming, and often a feeling of being compelled to perform useless acts, such as doing everything three times or continual washing of the hands. Abulia is not a comfortable laziness, but is attended by a sense of humiliation and inferiority. It shows itself in excessive hesitation and vacillation and in failure to accomplish anything of consequence. Sometimes the subject expends much effort, but fails to direct the effort towards the execution of his purposes. Some authorities have ascribed abulia to inertia or " low mental tension," some to an overdose of fear and caution, some to the paralyzing effect of repressed desires still living in the " unconscious." Mild degrees of it, such as are not uncommon, seem sometimes to be due to the distance of the goal. One has zest for reaching the goal, but not for the preliminaries.

An author, whose case was studied because he was accomplishing so little, was found to follow a daily program about as follows. He would get up in the morning full of confidence that this was going to be a good day. Before starting to write, however, he must first have his breakfast, and then a little fresh air, just to prepare himself for energetic work. On returning from his walk, he thought it best to rest for a few moments, and then one or two little matters seemed to demand attention; by the time these were done, the morning was too far gone, and he postponed writing till the afternoon, when the same sort of thing happened, and the great performance had to be put over till the next day. This man did better under a regime prescribed by his medical adviser, who commanded him to write for two hours immediately after rising, and make this his day's work — no more and no less than two hours. The definiteness of this task prevented dawdling.

How to secure action, from yourself, or from others if you are responsible for their action, is a big practical problem. A few hints on the matter are suggested by what precedes.

How to get action from yourself — how to liberate your latent energies and accomplish what you are capable of accomplishing. A definite purpose is the first requirement; without that one merely drifts, with no persistence and no great energy. The goal should be something that appeals vitally to you, and something which you can attain; not too distant a goal; or, if the ultimate goal is distant, there must be landmarks along the way which you can take as more immediate goals; for a goal that can be reached by immediate action enlists more present effort. The student puts more energy into his study when the examination is close at hand; and, although this fact is regrettable, it reveals a side of human nature that can be utilized in the management of yourself or others.

The more clearly you can see and measure your approach towards the goal, the more action. You cannot do so well when you simply " do your best " as when you set out to reach a certain level, high enough to tax your powers without being quite out of reach. You cannot jump so high in the empty air as you can to clear a bar; and, to secure your very best endeavor, the bar must not be so low that you can clear it easily, nor so high that you cannot clear it at all.

Getting action from other people is the business of parents, teachers, bosses, officers, and of every one who wishes to influence another. In war, the problem of "morale" is as important as the problem of equipment, and was so recognized by all the armies engaged in the World War. Each side sought to keep the morale of its own soldiers at a high pitch, and to depress the morale of the enemy. Good morale means more than mere willingness for duty; it means a positive zest for action. Some of the means used to promote morale were the following. The soldier must believe that his side has the right and will eventually win. He must be so absorbed in activities as to forget, in large measure, his own private concerns. Not only must he be enthusiastic for cause and country, but he must be strong for his division, regiment and company. Much depends on the officers who directly command him. He must have confidence in them, see that they know their business, and that they are looking out for the welfare of their men as well as expecting much from them. Competition between companies, regiments and arms of the service was a strong force tending towards rapid progress in training and good service in the field. Seeing that one's immediate group was accomplishing something towards the winning of the war was a powerful spur, while a sense of the uselessness of the work in hand badly depressed the morale of a group. "Nothing succeeds like success"; morale was at its best when the army was advancing and seemingly nearing the goal. Morale was also wonderfully good when the enemy was advancing, provided your side was holding well with a good prospect of bringing the enemy to a halt and baffling his offensive. On the other hand, nothing was so hard on morale as the failure of an ambitious offensive of one's own side; the sense of futility and hopelessness then reached its maximum — except, of course, for the case of obviously approaching defeat. The conditions of trench warfare imposed a strain on morale: no progress, in spite of the danger and hardship, no chance to get at the enemy or do anything positive.

The manager of an industrial enterprise has the same problem of morale to meet. It is his business to get action from people who come into the enterprise as servants. The main difficulty with the master-servant relation is that the servant has so little play for his own self-assertion. The master sets the goal, and the servant has submissively to accept it. This is not his enterprise, and therefore he is likely to show little zest for the work. He can be driven to a certain extent by fear and economic want; but better results, and the best social condition generally, can be expected from such management as enlists the individual's own will. He must be made to feel that the enterprise is his. He must feel that he is fairly treated, and that he receives a just share of the proceeds. He must be interested in the purposes of the concern and in the operations on which he is engaged. Best of all, some responsibility must be delegated to him, some room left for the exercise of his own initiative.

"Initiative" — that high-grade trait that is so much in demand — seems to be partly a matter of imagination and partly of motivation. It demands inventiveness in seeing what can be done, zest for action, and an independent and masterful spirit.

REFERENCES

1. Freud, S. *General introduction to psychoanalysis.* 1920. *New introductory lectures on psychoanalysis.* 1933.

2. Goodenough, F. L. *Anger in young children.* 1931.

3. Jones, H. E., & Jones, M. C. "A study of fear in young children." *Childhood Educ.*, 1928, 5, 136–243.

4. Morgan, J. J. B. "Overcoming of distractions and other resistances." *Arch. Psychol.*, 1916.

5. Richter, C. P. "Animal behavior and internal drives." *Quart. Rev. Biol.*, 1927, 2, 307–343.

6. Stone, C. P. ". . . sexual behavior of male rat." *J. Comp. Psychol.*, 1922, 2, 95–153. ". . . of female rats." *J. Comp. Psychol.*, 1926, 6, 73–83.

7. Troland, L. T. *The fundamentals of human motivation.* 1928.

8. Warden, C. J. *Animal motivation.* 1931.

CHAPTER XIII

FEELING AND EMOTION

From a purely objective and social point of view, it may make no difference how the individual feels, provided he goes through the right motions, but that is not the individual's way of looking at the matter. From his personal point of view feeling and emotion could not be omitted without missing the point of the whole story. A psychology without them would be on a par with a motion picture of an orchestra in action, without the sound.

THE FEELINGS

It is remarkable how many words there are in common use for different feelings and emotions. It would be no great task to find a hundred words, some of them no doubt synonymous, to complete the sentence, "I feel ——." Here are a few names of feeling and emotions, roughly grouped into classes.

Pleasure, happiness, joy, delight, elation, rapture
Displeasure, discontent, grief, sadness, sorrow, dejection
Mirth, amusement, hilarity
Excitement, agitation
Calm, contentment, numbness, apathy, weariness, ennui
Expectancy, eagerness, hope, assurance, courage
Doubt, shyness, embarrassment, anxiety, worry, dread, fear, fright, terror, horror
Surprise, amazement, wonder, relief, disappointment
Desire, appetite, longing, yearning, love
Aversion, disgust, loathing, hate
Anger, resentment, indignation, sullenness, rage, fury

The first word in each class is intended to give the keynote of the class. Other classifications could be made, and the classes could be made broader or narrower. Two broad classes, pleasant and unpleasant, would include most of the feelings. Still, you cannot say that the names simply designate different degrees of pleasantness or unpleasantness. Rapture and hilarity are both intensely pleasant, but scarcely the same; nor are fear and disgust the same, though both unpleasant. The fact is that there are many kinds of pleasant feeling, and of unpleasant. Some of the words do not indicate whether the feeling is pleasant or unpleasant; excitement may be happy excitement or unhappy excitement, and the same is true of expectancy and of surprise.

Wundt's three dimensions of feeling. This great leader in experimental psychology (who established the first active psychological laboratory in 1879) hoped to introduce some order into the motley variety of feelings by a system of three dimensions, analogous to latitude, longitude and altitude, by reference to which any actual feeling could be completely located. States of feeling can be arranged in a series from the most pleasant down through lower degrees of pleasantness and through a neutral zone over into the minor and then the major degrees of unpleasantness. This pleasantness-unpleasantness dimension was universally recognized and commonly assumed to be the only scale of feelings. But states of feeling can be arranged in another series, from the most excited to the most calm, quiet, subdued or numb. Wundt proposed, then, to take numb feeling as the reverse of excited feeling, and thus he had his second dimension, excitement-numbness. For his third dimension, he selected tenseness-release, which might also be called expectancy-release. In expectancy you are waiting for something to happen, in relief or release that something has happened and abolished the expectancy.

Wundt's scheme has some value, even though it is almost too neat to fit all the facts of feeling. There may be other dimensions worthy to be placed alongside of these three, such as desire-aversion, or such as familiarity-strangeness, already noticed in our study of recognition.

Feeling distinguished from overt action. Feeling seems like a passive state of the organism, rather than an activity; and it is internal rather than overt activity. Whereas overt activity deals with external objects, feeling by itself produces no external results. Yet feeling is not out of touch with the external situation. Unpleasant feeling favors getting rid of something and changing the situation; pleasant feeling favors keeping things as they are. But the feeling can be there without any definite overt action to maintain or change the situation; and on the other hand, overt action can occur with a minimum of feeling.

Feeling distinguished from observation of facts. Feeling is different from knowing. It does not consist in knowing facts of the world outside us, nor even in knowing facts regarding ourselves. A pain may be simply felt, or it may be observed as the indicator of some fact. A pain from the region of the stomach may be noticed carefully with the object of deciding whether it is the pain of indigestion or a hunger pang; or it may be taken simply as a painful feeling. Sensations, then, can be taken in two ways. In observation, we take them as indicators of facts, while in feeling we take them as a mass.

Feeling at one time is strong, even overwhelming, while at another time it exists only as an undercurrent. Or we may call it a background, the foreground consisting of the facts observed and the acts intended at the moment. Only a few among the sensations present at any moment are actually used as indicators of facts; the rest of the mass remains unanalyzed and indefinite. When you feel dull and heavy, if you notice the details you become aware of dull pain in the eyes, neck, elbows or knees and of dull pressure in the chest and abdomen; these various dull sensations, when taken as an unanalyzed mass, constitute the general dull feeling.

The dull, uncomfortable feeling that is apt to occur during protracted sedentary work can be relieved by limbering up the joints with a little exercise, or by lying down for a few minutes. The various dull pains from the joints and from the interior of the trunk are removed by these means.

Feeling usually dominated by the life of facts and acts. The background of bodily feeling may be almost lost when one is absorbed in watching something, doing something or thinking of something. Bruises received during an active game may remain unnoticed till the game is over. Eye ache remains unnoticed while the story lasts. The audience sit motionless while the speaker is at his best, and start easing their several discomforts as soon as he becomes tiresome. Thus feeling is dominated and kept down by absorption in activity.

Observation of facts and dealing with them belong together in what is sometimes called the life of relation with the environment, while feeling belongs with the internal life of the organism. Thinking, making use as it does of past observations and concerned as it largely is with planning for future action, belongs with observation and overt action in the life of external relations. Observation, thinking and acting differ from feeling in being more analytical, or intellectual, or brainy. The skillful handling of a well observed situation is a brainier activity than merely feeling pleased or hopeful or discouraged. This brainy life of relation dominates at certain moments, and pushes the feeling of internal condition away into the background. At other times, the life of relation loses its grip or takes a rest, and feeling comes to the front.

Feeling is both sensory and motor. On the sensory side, it is the sensation-mass, unanalyzed and not utilized to indicate facts. On the motor side, it is the general set or attitude of the organism. Pleasantness is the general set for keeping the situation as it is, unpleasantness for getting rid of the situation. Excitement is the set towards great activity. Expectancy is the set or readiness for something to happen. In mere feeling, there is no set for any particular act. Feeling is diffuse and massive, on the motor as well as on the sensory side.

EMOTION

Emotion is a "moved" or stirred-up state of the organism. It is a stirred-up state of feeling — that is the way it appears to the individual himself. It is a disturbed muscular and glandular activity — that is the way it appears to an external observer, who sees the clenched fists and flushed face of anger and the tears of grief, or who hears the loud laugh of merriment and the pleading tones of love.

Each emotion can be located in the tridimensional scheme of feeling, but such an analysis does not do full justice to the emotion. Fear is a state of excited, unpleasant expectancy, and mirth is excited, pleasant relief, but each is something more. Each emotion is a sensation-mass, and each is at the same time a motor set. Fear is a set for escape, and anger for attack. These sets are more specific than the sets of mere pleasantness and unpleasantness.

How emotions are defined and distinguished one from another. Though we all know the emotions as matters of personal experience, no one seems to be able to describe them adequately either as subjective feelings or as muscular and glandular activities. How, then, can we tell the emotions apart? How does it come about that we have that large vocabulary of names of different emotions? The several emotions are distinguished, in practice, by stating the *external situation* in which each occurs and the type of *overt response* made to the situation. As Carr has said, "The various emotions can be readily identified and defined only in terms of the behavior situations in which they occur" (5).

Fear is the emotional response to danger; anger, to interference; joy, to success; surprise, to any unexpected happening; mirth is the emotion that goes with laughing; grief, with sobbing; and so on. Any particular emotion is the stirred-up state appropriate to a certain situation and overt response.

It is true that the situation and overt response may occur without emotion. You may fight off an attack without anger, or dodge an automobile without fear. If the overt response is prompt and successful, emotion may not be aroused. If the brainy life of relation dominates the organism at the moment, the emotional response is minimized. But if the situation gets out of hand, the emotion appropriate to the situation surges up. From the situation and overt response, then, you cannot safely assert that the individual is undergoing an emotion; but you are reasonably sure that, if he is undergoing an emotion, it is the one that usually goes with that situation and that response.

How emotions are revealed — expressive movements. Smiling, laughing, scowling, pouting, sneering, sobbing, screaming, shouting and dancing up and down accomplish no important external result, except for their effects on other people. What is the sense of these movements? At first thought, the question itself is senseless, the movements are so much a matter of course, while on second thought they certainly do seem queer. What sense is there in protruding the lips when sulky, or in drawing up the corners of the mouth and showing the canine teeth in contempt? Darwin, after studying these movements in men and animals, suggested that they were *survivals* of acts that were once of practical utility in the life of the individual or of the race.

Shaking the head from side to side, in negation or unwillingness, dates back to the nursing period of the individual, when this movement was made in rejecting undesired food. The nasal expression in disgust was originally a defensive movement against bad odors; and the set lips of determination went primarily with the set glottis and rigid chest that are useful in muscular effort. Such movements, directly useful in certain simple situations, become linked up with similar but more complex situations in the course of the individual's experience.

Showing the teeth in scorn dates back, according to Darwin, to a prehuman stage of development, and is a useful act in animals like the dog or gorilla that have large canine teeth. Baring the teeth in these animals is a preparation for using the teeth; and often it frightens the enemy away and makes actual attack unnecessary. This movement, Darwin urges, has survived in the race even after fighting with the teeth has mostly gone out. Many other expressive movements can be traced back in a similar way, though it must be admitted that the racial survivals are usually less convincing than those from the infancy of the individual.

Learning to control emotional expression. Some expressive movements, like smiling, laughing, crying, sobbing and screaming, are certainly unlearned; others are picked up by imitation. All expressive movements become attached or conditioned to situations that originally could not arouse them. As the child grows up, he learns to *moderate* his expressions of anger and of glee, and he even learns to *conceal his emotions.* He is ridiculed for crying or showing fear; he gives offense by showing anger, or by crowing and strutting in pride. Politeness requires him to smile many times when he feels like scowling, and to exclaim in surprise at information that is perfectly trite. Thus social pressure trains him to keep his feelings to himself. At the same time, other people are always trying to discover how he does feel, and he himself scans the faces of other people in the attempt to *read their emotions.* There is a race between concealment of the emotions on one side and detection of the emotions on the other, like the race in warships between defensive armor and penetrating projectiles.

On the whole, expressive movements tend to become reduced

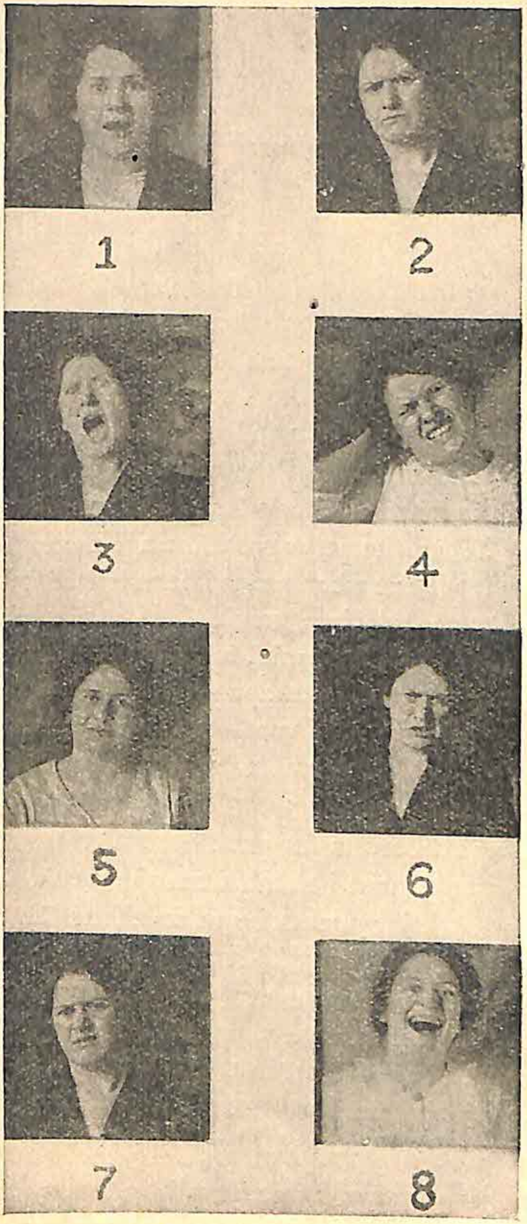


FIG. 68. — (From Feleky, 6.) Facial poses for several emotions. Give each one a name that fits; the following list includes the names most used in describing these particular poses: horror, laughter, sharp pain, pleasant feeling, surprise, disgust, determination, hate.

as the individual grows older. But in make-believe play and on the stage, there is a development in the opposite direction, in the direction of *depicting the emotions*. There is a language of the emotions, composed of gestures and postures, of exclamations and inflections and tones of the voice, of facial expressions. This language is no doubt based upon the unlearned expressive movements, but it has become standardized through long ages, and now is largely a matter of social custom and convention. The child finds this language in use, and appropriates it to some extent. Actors appropriate it to a large extent, and introduce their own individual improvements. The result is that this language of the emotions is much more expressive than the average adult's facial and vocal behavior during emotion. When the actor poses for an emotion, he makes full use of his face; but when the ordinary citizen is in an emotional state, his face may be a mask.

How expressive is the facial language of emotion? To obtain evidence on this question — obviously an important question for social psychology — the experimenter presents photographed facial poses and asks for judgments as to the emotion intended by each pose. The judgments of the same pose by different observers vary and at first create the impression that emotion cannot be read from the face alone. More careful study of the judgments, however, shows that the errors committed are relatively small. A pose for "love" will often be called "happiness" but never "contempt." It is possible to arrange a scale of emotions from love at one end to contempt at the other, with anger about in the middle, and to distribute along this scale the judgments passed on each pose. The distribution shows the judgments for each pose concentrated about a center at or near the intended emotion. There is on the whole a very good correlation between the pose and the judgments. Though the finer shades of emotion are not very successfully conveyed by the face, the general character of the emotion is well depicted. If so much as this can be done with still photographs of the face alone, the living actor, with posture and gestures visible as well as the face, would certainly convey the intended emotion very completely.

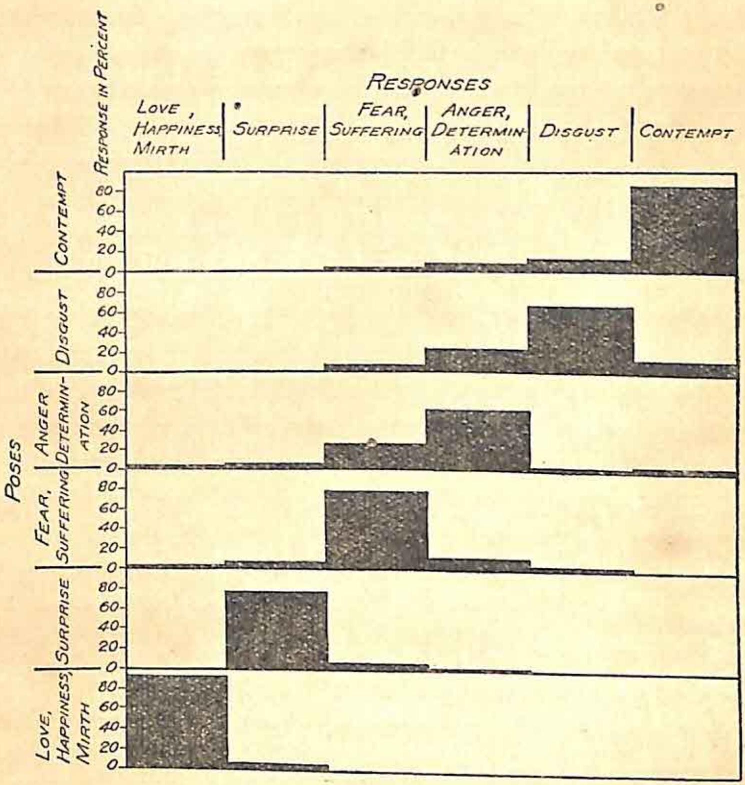


FIG. 69. — (Data from Feleky, 6.) Distribution of judgments of facial poses along a scale of emotions. There were 19 poses and 100 judges for each. The distribution of judgments for each class of poses is shown along a horizontal base line, and the frequency of each class of judgments is indicated by the height of the distribution in successive columns. The general oblique slant of the whole diagram is very clear, indicating a fairly close positive correlation between the pose and the judgment.

Unposed facial expression. Photographs of the spontaneous expressions of unhistrionic adults in the throes of genuine emotion are not easily obtained. In the psychological laboratory, strangely enough, more success has been achieved in arousing unpleasant than pleasant emotions.

In one experiment (7), lasting over three hours, a series of situations was presented for the purpose of arousing a variety of emotions, the series beginning with music and serious reading, and proceeding to startling, embarrassing, disgusting and painful situations, which became so drastic at the close as to cause weeping or vigorous angry language from nearly all the subjects. An attempt was made to analyze the facial expressions in terms of the different muscles concerned — those that raise or lower the brow, those that widen or narrow the eyes, those that "stick up" the nose, those that pull the lips upwards, outwards or downwards, etc. The object was to see whether there were any patterns of facial movement characteristic of the different emotions, but the result was rather negative. One individual differed from another in his characteristic expression; but the different situations failed to produce any strikingly different facial expressions. The eyes were apt to be narrowed in most of the situations, and the mouth was apt to be drawn into some sort of a smile or half smile — a sort of "grin and bear it" expression. There was more concealment than free expression.

Vocal expression of emotion. The voice is perhaps more expressive than the face. The speaking voice is more expressive than the singing voice, because it takes on more of the harsh quality, when needed, and especially because it is free to slide up and down the pitch scale. The rising inflection in questioning, the falling inflection in finality, the circumflex inflection in sarcasm, are very expressive. The little word, "No," can be made to carry several meanings according to the inflection. Monotone goes with dull feeling, slides and jumps from low to high and from high to low go with excitement. The connection of excitement with loud and high-pitched voice is probably natural and unlearned, but how much more of the language of voice, apart from speech, is unlearned and how much is dependent on social custom, we can only guess at the present time. When words, with their associated meanings, are added to vocal tones and inflections, the emotional expression becomes clear and finely shaded. Just the printed word, HORROR, in a newspaper headline, creates an emotional atmosphere.

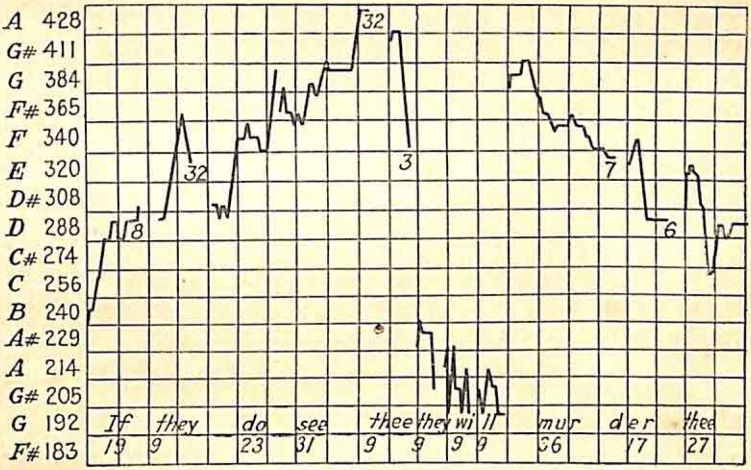


FIG. 70. — Inflection of the voice in emotional speaking. (From G. M. Merry, 8.) Changes in the pitch of the voice measured from a phonograph record of Julia Marlowe's rendition of Portia's speech in "The Merchant of Venice."

Breathing and heart beat in emotion. Excitement, attended as it is apt to be with muscular activity, is for that reason attended also by increased breathing and heart action. A startling noise checks breathing and first stops and then hastens the heart. Breathing is apt to be shallow during a brief period of concentrated attention, and at the end of such a period there often appears a deep inspiration followed by a rather forcible expiration. This "sigh" makes up for the insufficient respiration of the preceding period. The sigh of grief or longing may perhaps arise in the same physiological manner.

Much interest attaches to the *inspiration-expiration ratio,* or I/E ratio, as an indicator of emotional conditions. This ratio is obtained from a breathing record by dividing the time occupied by inspiration by the time of expiration. In quiet breathing, inspiration takes less time than expiration, and the ratio is about .70, with some variation. In amazement, the chest is held in the inspiratory position, with quick gasps of expiration followed immediately by inspiration, and the I/E ratio goes up to as much as 2.00. In laughing, on the contrary, the breath after being drawn in quickly is emitted in a series of puffs, so that the ratio goes down to .30. Something of the same kind takes place in talking and even in whispering and silent speech. What will happen, then, if a person is doing mental multiplication under difficulties? He is likely to whisper the numbers — just as we saw once before in a distraction experiment (see p. 324) — and so decrease his I/E ratio. Now suppose that a person on the witness stand is giving false answers to a series of questions, trying to make his answers plausible. There will be more intense inner speech during this process than if he were giving true and easy answers to the questions asked him. As a matter of fact, in laboratory "lying," there is a decrease in the I/E ratio.

The *blood pressure,* or pressure in the arteries, depends on complex physiological factors, the chief of which are the output of blood from the heart, and the resistance offered by the small arteries to the passage of blood. In the lying experiment, the blood pressure rises, in perhaps 80% of the cases. Possibly this indicator of deception, as well as the I/E ratio, could be used in the police examination of suspects; and indeed the method has been used with some success, but must be regarded as still in an experimental stage. There is no mysterious connection of lying with blood pressure or with breathing. The blood pressure is apt to rise in excitement, whether the excitement is brought on by the exigencies of making up a plausible story, by taking an intelligence test, by watching a "sexy" motion picture, or by receiving strong electric shocks. In the prolonged emotional experiment described a few pages back, the blood pressure rose towards the close of the series of disturbing situations. It also rose momentarily in surprise.

Other signs of emotion. The cat's hair rises in fear or anger, and goose flesh in the human being is the same response, produced by tiny muscles under the control of the so-called "sympathetic" nerves. The pupil of the eye dilates in the same conditions, from the action of another, related nerve. The sweat glands are similarly aroused, and in strong emotion the perspiration may stand in beads upon the skin. Even in momentary thrills of fear, surprise, embarrassment or expectancy, the sweat glands are stimulated to a slight degree by their nerves, and the result is a momentary change in the electrical condition of the skin, which can be registered by a galvanometer and is called the *psychogalvanic reflex*. This electrical change is perhaps the most delicate indicator of emotion that the laboratory has yet produced.

ORGANIC STATES IN EMOTION

Traditionally, the heart is the seat of the emotions, and this means, no doubt, that they are felt in the general region of the heart; and other ancient "seats," in the diaphragm or in the bowels, agree to the extent of pointing to the interior of the trunk as the general location where emotions are felt. There may be something in this primitive location of the emotions; there may be some internal disturbance in strong emotion that makes itself felt by obscure sensations.

To understand what goes on in the interior of the trunk, we need to add to our previous information on the endocrine glands (p. 116) some knowledge of the nerve supply of this region.

The autonomic nerves. These are the nerves that run to the heart, blood vessels, lungs, stomach, intestines and other viscera, and also to the sweat glands, the little muscles of the hairs, and the iris of the eye. They run, that is, to the "smooth muscle," a slower-acting, but more automatic type of muscle than that of the limbs, and they run also to glands. These nerves are composed of extra-slender nerve fibers, which grow out from cells in the brain stem and cord, and so are part of the general nervous system, not a separate system as was formerly believed. There are three divisions of the autonomic, upper, middle and lower. The upper division grows out from the brain stem, and consists principally of the "vagus" or wandering nerve, which, among other effects, slows the heart beat, but stimulates the glands of the stomach to pour out the gastric juice, and the muscular wall of the stomach to make its churning movement. Thus the upper autonomic is active in digestion. The middle division of the autonomic consists of the "sympathetic" nerves, which come out from the spinal cord at the level of the chest, and which have the opposite effects on the heart and stomach to those of the upper division. The sympathetic hastens the heart and retards or checks stomach activity, and has the other effects just described as signs of emotion. The sympathetic in its wide distribution also overlaps the lower autonomic (which comes from the lower part of the spinal cord), and it antagonizes the latter's stimulating effects on the pelvic organs.

The autonomic is certainly under the influence of the cortex, directly or indirectly, since something you merely *think* of may hasten or slow the heart, may make you blush or pale, may help or hinder digestion. There is a little part of the interbrain that is a center for the autonomic nerves. This fact becomes the more interesting when we learn that many students of the brain are convinced that the interbrain is somehow concerned in emotion. Injuries to the interbrain often produce uncontrollable laughing or weeping.

The organic state in anger. Suppose we have a cat that knows us well, and after feeding her a good meal containing some substance that is opaque to the X-rays, suppose we place her on a table and pass X-rays through her body, so as to get a visible shadow of the stomach upon the plate of the X-ray machine. Well and good; the cat is contentedly digesting her meal, and the X-ray picture shows her stomach to be making rhythmical churning movements. In comes a fox terrier and barks fiercely at the cat, who shows the usual feline signs of anger; but she is held in position and her stomach kept under observation — when, to our surprise, the stomach movements abruptly cease, not to begin again till the dog has been gone for about fifteen minutes. The churning movements of the intestine cease along with those of the stomach, and, as other experiments show, the gastric juice stops flowing into the stomach. The whole business of digestion halts during the state of anger. So anger is an organic state, without doubt. In man also it is an excellent rule not to eat while angry (2).

Stomach inhibition is not the only internal response during anger. The heart, so long regarded as the seat of emotions, does beat more forcibly than usual; and the diaphragm, where the ancient Greeks placed the emotions, does make strong breathing movements. The medulla of the adrenal glands (p. 115) is aroused by the sympathetic nerves and discharges its hormone into the circulation. The adrenin reinforces and prolongs the changes produced by the sympathetic nerves in the stomach, heart, blood vessels and other organs.

The sympathetic-adrenal organic state as a useful preparatory reaction. Apparently the internal condition in fear of the energetic type is the same as in anger. This organic state, though useless and perhaps a handicap in most of the activities of civilized man, does make a first-class preparation for intense muscular activity, such as is demanded by physical flight or fighting. Rapid circulation and abundant fuel are positively useful, and the halting of digestion relieves the organism from dividing its energies between activities that can afford to wait and those that must be pushed now or never.

Essentially the same organic state occurs in strenuous muscular activity such as running a race. It has been found in football players before a game, and in students just before an examination. Probably the organic state was useful to the football players, and far from useful to the students. But in either case the emotion was scarcely fear or anger; it was described as being "all on edge" or "all keyed up." The state was one of *excitement*. Anger is excitement with the addition of its own peculiar quality; and fear of the energetic sort is excitement plus its own peculiar quality. These peculiar qualities have to do with the overt activity for which the organism is set; for attack in anger, for escape in fear.

In anger and fear, then, we find (a) a set of the organism towards a certain type of overt activity, and (b) an organic state, which amounts to a preparation for the overt activity. The set for the overt activity is felt by the individual as an impulse to attack or to escape, and the organic state is felt as excitement, and these two component feelings make up the total feeling of anger or of fear.

Organic states in other emotions. Can we find similar combinations of particular organic states with particular sets for overt activity, and can we regard emotions generally as made up after the model of anger? The studies already cited of sex appetite show a similar pattern (p. 120).

This scheme or pattern can be seen easily in the case of hunger and appetite for food. There is the organic state of food-depletion, with stomach movements and readiness of the salivary and gastric glands for active secretion, and there is the set of the organism for the overt behavior of food-getting and eating. Hunger, to be sure, is not usually called an emotion, but rather just an organic state and sensation, largely because the hunger pangs are localized as coming from the stomach region and are noted as indicators of the fact of organic hunger. But if the hunger sensations are not very intense, they may not be definitely localized, and the individual may simply feel an appetite for food, which certainly should be classed as an emotion.

Fatigue from muscular activity is an organic state consisting largely in the accumulation in the muscles and in the blood of the waste products of muscular action, especially carbon dioxide and lactic acid. These substances, carried about by the blood, lower the activity of the organs through which they circulate. There may be local fatigue sensations in the exercised muscles and joints, and also a general diffuse weariness. There is clearly a set towards the overt behavior of resting. The organic state predisposes the organism for rest and unfits it for activity. Thus fatigue fits nicely into the scheme.

What may be the nature of the organic state in drowsiness we cannot say, but it seems clear that there is an organic state, and that it predisposes for sleep. If we allow ourselves to regard sleep as a form of overt behavior, then our scheme works all right here again. And it works with thirst as well, though the sensation of thirst is so well localized that we do not call it an emotion.

Emotions without known organic states. Several of the best-known emotions do not fit neatly into the scheme suggested by anger, because their organic states, if any, are not known.

Surprise is allied to fear. The psychogalvanic reflex, which is an indicator of the activity of the sympathetic nerves, is readily aroused by surprising stimuli. In surprise, the activity in progress is brought to a sudden halt, and the organism attends to something new and possibly dangerous that has entered the situation. The internal response is a slight beginning of the activity that goes with danger. The overt activity is a slight beginning of escape. Surprise, then, is no great exception to our rule.

Mirth or amusement is the emotion that goes with laughter. Is there possibly an organic state here? All we can say is that laughter favors digestion, removes anger and counteracts fear — facts suggestive of some organic process opposed to that of anger and fear.

Grief, if we may so call the emotion that goes with the baby's crying, is like mirth in having no known organic state.

Joy, though akin to mirth, often occurs in situations that would not be called amusing. It would be going too far to assert that joy has no organic state; it would be going just far enough to say that we do not know.

In *curiosity*, though the feeling is often strong enough and different from any of the other emotions, it would seem improbable that there is any special organic state. The overt activity consists in exploring what has aroused curiosity.

All in all, this brief survey of emotions shows them all possibly but not certainly fitting into the scheme suggested by anger. There is always a set for some overt activity, and almost always there is the possibility of an organic state.

Moods. A mood differs from an emotion in being less in intensity and longer in duration. While in an angry mood, a person may not be actually angry, but he is all ready to be made angry by the least provocation. Such a mood is often a hangover from an active emotion. Let a man be " all riled up " by something that has happened at the office, and he comes home quite ready to take it out on his wife and children. Slightly irritating performances of the children, that usually would not arouse an angry response from him, do so this evening because that thing at the office has made him cross. In the same way, a nervous or jumpy mood may follow a dangerous experience. From the fact that the cat, in the X-ray experiment, showed the internal state characteristic of fear and anger for quite a while after the irritating dog had gone away, we may conclude that angry and timorous moods are due, in part at least, to the persistence of the organic state set up in active emotion.

But what shall we say, then, of the persistence of a jovial mood after a good laugh, or of a happy mood after the joy of success? Perhaps there is an organic state, here too, that outlasts the active emotion.

Moods are however not always the after-effects of active emotional outbursts. Euphoria seems to be the mood that goes with excellent physical condition, and a depressed or "blue" mood may mean simply an unfavorable physical condition. Lassitude and the morning grouch may be simply the mood of one who is not yet fully awake.

DEVELOPMENT OF THE EMOTIONAL LIFE

Undoubtedly the emotional life of the child develops by maturation as well as by learning. Sex emotion, certainly, cannot fully make its appearance till sex maturity brings the hormones and organic states that are essential to the emotion. The child's fears increase in number and scope because he grows to take account of a wider environment, though some of them are learned by the conditioned reflex process, already illustrated (see pp. 254, 309). The child learns to moderate his crying and other too energetic expressions of emotion, and to substitute laughter for fear or anger in many situations. The practical life of relation comes to dominate more and more over the emotional life, so that the child's behavior becomes less emotional as he grows older. A scale for emotional age, after the analogy of the Binet scale for mental age, would consist in large part of tests for *not* being afraid or angry or grieved or curious at things which regularly arouse those emotions in the younger child.

Sentiments. This term is used in psychology to refer to any complex emotional attitude towards an object, person or situation, an attitude built up in the course of experience. The baby's mother frequently gives him pleasure, but sometimes treats him sternly. Various emotional responses become attached to this same person. The adult's sentiment towards a child is likely to combine tenderness and amusement. Hate is a sentiment, or complex permanent attitude towards a person, rather than any one emotion. Love is more than any single emotion, and patriotism is another instance. The higher emotions, esthetic, social, religious, are sentiments towards certain types of objects and are built up in the individual's experience, with much assistance from the social environment.

THEORY OF THE EMOTIONS

The task now before us is that of putting together the main facts that have emerged from our study of feeling and emotion, with the object of discovering (a) the difference between emotional behavior and unemotional, and (b) the difference between one emotion and another.

The main facts that we have to work with are:

1. The situation in which the individual is placed, and his intellectual perception of the situation.

2. His set for a certain overt activity or for a certain result, such as escape from danger.

3. The organic state, present in some emotions, though perhaps not in all, this state not being the same for all emotions, nor yet different for every different emotion; it appears to be the same in anger, fear and other excited states, but something else in sex appetite or in food appetite or in fatigue.

4. The sensations, set up by the internal organic activity, by expressive movements, and by the overt activity, these sensa-

tions being taken as a mass in feeling and emotion, and not as indicators of facts.

5. The greater or less dominance of the organism by the practical or brainy life of relation as against the more diffuse and undirected type of activity which occurs in strong feeling and emotion.

The James-Lange theory of the emotions. The American psychologist James, and the Danish physiologist Lange, independently of each other, put forward this theory about 1880, and it has ever since remained a great topic for discussion. According to the theory, a conscious emotion is simply a mass of sensations from all over the body, especially from the internal organs. The emotion is the *way the body feels* when in a disturbed organic state, and when going through the expressive and overt movements characteristic of the emotion.

James says, we do not tremble because we are afraid, but are afraid because we tremble. He means that the conscious state of fear is composed of the sensations of trembling (along with the sensations of other muscular and glandular responses). He means that the mere knowledge of present danger is not the feeling of fear and that the feeling only comes with the organic and overt response. As soon as these responses begin to take place, and to produce a mass of disturbed sensation, then the feeling of fear wells up. " Without the bodily states," James says, we might " see the bear, and judge it best to run, receive the insult, and deem it right to strike, but we should not actually *feel* afraid or angry." The " emotional warmth " of the experience comes from bodily sensations.

In appraising the value of this theory, we have to consider what theory it was intended to supplant. It was aimed at the common-sense theory which supposes that the sight of the bear arouses the feeling of fear, and that this feeling gives rise to the changed organic state, as well as to the overt movements of escape. The James-Lange theory holds, on the contrary, that the organic state precedes the feeling and gives rise to it; and that therefore the feeling would be impossible without the organic state. What arouses the organic state, according to the theory, is the intellectual perception of danger, not the feeling of fear; the feeling arises from the organic state.

Evidence for and against the James-Lange theory. Sherrington attempted a physiological examination of this question (9). He took a dog that had been in the laboratory for months, and that showed a markedly emotional temperament, affectionate toward some individuals and hostile to others, and performed certain nerve-cutting operations which deprived the animal of nearly all sensation from the interior of the trunk. This loss of sensation produced no obvious change in the dog's emotional behavior. "Her anger, her joy, her disgust, and when provocation arose, her fear, remained as evident as ever." A visitor who had previously awakened her anger was again received with signs of rage — wide-open eyes, dilated pupils, vicious growls — while the attendant who fed her was received with all signs of joy.

This experiment certainly proves that the overt behavior and expressive movements of emotion do not depend upon sensations from the interior of the trunk. Of course, it is impossible to say, absolutely, what the dog *felt*. It might be argued that the dog went through the external movements with no emotional feeling. But so strained an interpretation of the dog's behavior could only be justified by very strong evidence from some other source of the truth of the James-Lange theory.

Another physiological experiment carries us a step further. The sympathetic nerves of a cat were severed, and the whole organic state of anger, dependent on those nerves, was made impossible, and still the cat continued to show the overt behavior and expressive movements of anger — growling, hissing, showing the teeth, drawing back the ears, lifting the front leg to strike. We see, then, not only that the *sensations* from the organic state are unnecessary for giving rise to the external behavior of anger, but that the organic state itself is unnecessary.

What would happen if the organic state characteristic of fear and anger could be artificially produced, without any external stimulus for fear or anger being present? This experiment has been tried, by giving adrenin to human subjects — under medical supervision, as an overdose has bad effects. Some of the subjects, after taking the adrenin, said they felt "on edge," as before a game or race in which they were to participate. Some of them reported that they "felt as if they were afraid, though of course they were not really afraid," or "as if they were awaiting a great joy," or "as if they were going to weep without knowing why." The feelings produced by the adrenin were all "as if." But complete emotions were specially easy to arouse while the subjects were adrenized. The hormone, though not actually producing emotion, had put them into an emotional mood (4).

In an experiment of quite a different type, the blindfolded subject was seated in a mechanical chair which was suddenly tilted backward into a horizontal position. Apparatus registered his breathing and heartbeat which were much disturbed. The subject made a movement to save himself and experienced the feeling of fright. He returned on another day and was seated in the same chair. As he now anticipated the sudden drop he took it without any overt movement to save himself, but his heart and respiration again betrayed some internal disturbance though less than on the first day. The subject reported that he did not experience fear on this second occasion. Here we have the organic state of fear, occurring when the subject was so well adjusted to the situation that he made no overt escape movement; and the feeling of fear was absent. About twenty subjects gave concordant results (1).

The upshot of all the experimental evidence seems to be that an organic state, while predisposing the individual to a certain emotion, is neither necessary nor sufficient for the emergence of emotional feeling and behavior. Under ordinary conditions, to be sure, a certain organic state is present in fear and anger, and it doubtless contributes to the frightened or angry state. As the same organic state occurs in both fear and anger, the difference between these two emotions must lie in the set for escape in one and for attack in the other. But this same organic state occurs in strenuous muscular activity such as running a race, though the runner is neither frightened nor angry, but may be quite cool and calculating. He may keep his head and still have the physical benefit of the organic state. The sprinter has the same organic state as a man who is fleeing in terror. He gets the same sensations from the internal organs and from the running muscles. He ought, then, according to the James-Lange theory, to have the same frightened feeling. The theory certainly breaks down here (3).

The difference between emotional and unemotional activity does not lie in the presence or absence of an organic state, nor in the presence or absence of a certain overt activity, nor in the presence or absence of certain sensations. It depends on the degree to which the individual keeps his head, that is, on the degree to which the brainy life of relation dominates his whole activity. If he completely loses his head, his sensations become a diffuse mass of feeling, and his set for overt activity becomes a blind struggle.

Under what conditions is the individual likely to lose his head? When does the brainy life of relation relax its grip and leave emotion unfettered? When the situation cannot be handled successfully. When the goal cannot be reached quickly enough. When the goal has been reached, and there is nothing to do but to burst forth in joy. When the organic state is strong and lively, like a horse that is all warmed up and hard to control. During intoxication, when the cerebral cortex, concerned in the "brainy life of relation," is partly thrown out of function and ceases to dominate the lower parts of the brain that, left to themselves, carry out the blinder and more impulsive life of emotion.

REFERENCES

1. Blatz, W. E. "The cardiac, respiratory, and electrical phenomena involved in the emotion of fear." *J. Exper. Psychol.*, 1925, 8, 109–132.

2. Cannon, W. B. *Bodily changes in pain, hunger, fear and rage.* 2d ed. 1929.

3. Cannon, W. B. "The James-Lange theory of emotions: . . ." *Amer. J. Psychol.*, 1927, 39, 106–124.

4. Cannon, W. B. "Neural organization for emotional expression." *The Wittenberg Symposium.* M. Reymert, ed. 1928. esp. p. 262.

5. Carr, H. A. *Psychology.* 1925. esp. p. 278.

6. Feleky, A. *Feelings and emotions.* 1924.

7. Landis, C. "General behavior and facial expression." *J. Comp. Psychol.*, 1924, 4, 447–509.

8. Merry, G. M. "Voice inflection in speech." *Psychol. Monog.*, 1922, 31.

9. Sherrington, C. S. *The integrative action of the nervous system.* 1906. esp. p. 259.

10. Beebe-Center, J. G. *The psychology of pleasantness and unpleasantness.* 1932. A comprehensive study of the experimental evidence on the feelings.

CHAPTER XIV

THE SENSE OF SIGHT: VISUAL SENSATION AND PERCEPTION

Of the main problems of psychology, mentioned in the opening chapter, there is one which has so far received only incidental notice. The individual, we said, participates in the activities going on in the environment; he participates intelligently and effectively. He knows the environment and he accomplishes environmental results. The relationship between the environment and the individual was embodied in the formula:

$$W - S - O - R - W$$

to be read that the environment acts on the individual by stimuli, and that the individual acts on the environment by muscular and glandular responses. The question is how the individual can know the environment, and actually do things in the environment, when he cannot get outside the limits of his own skin, either in receiving stimuli or in activating his effectors. How does the individual penetrate beyond his receptors and know the environment?

What do we see? The common sense answer is that we see the objects and happenings that are before our eyes. But when we ask how we can see an object out there, we learn from physics that what we actually see is light, emitted from the sun or some other luminous body and reflected from the object into our eyes. Do we see objects or do we see light? Do we see the colors of objects or the colors of light? This last question is a very practical one to the landscape painter. Suppose his subject to be a white cow lying on the green grass in the shade of a tree. He sees the cow to be white and the grass to be a light green, but if he lays on pure white for his cow and light green for his grass, he has altogether lost the shade of the tree. To reproduce the picture that he has before his eyes, he has to darken the cow and the grass, he has to paint the white cow gray and the light green grass dark green. The painter has to learn to see lights and shades and mere colors, instead of the colors of objects. It is a difficult task for the novice in painting to see light and the colors of light — which might be called picture colors — and to get away from the customary seeing of objects and their colors. For ordinary purposes it is more useful to see the colors of the objects themselves than to see the picture colors which those objects deliver to the eye at any moment. There is no doubt that ordinarily we go as far as we can away from seeing light and towards seeing objects.

Sensation and perception. Evidently there are two meanings of the verb "see," and it would be desirable to have two psychological terms to mark the distinction. Let us call the seeing of light by the term "visual sensation," and for seeing objects or environmental facts let us use the term "visual perception." Similarly in the case of smell, olfactory sensation is the sensing of the odor stimuli that enter the nose, while olfactory perception is the smelling of odorous substances present in the neighborhood. In general, when we speak of sensation we are thinking of stimuli and investigating the relationship of the individual's experiences and activities to the various stimuli which reach his receptors; and when we speak of perception we are thinking of objects and are investigating how well the individual's experiences and behavior correspond with the objective facts. In his practical "life of relation" with the environment, the individual is bent on perception; but his receptive apparatus seems built for sensation. He certainly knows the environment only by utilizing the stimuli received.

VISUAL SENSATION

Before following up any further the process of seeing objects, we need to know something of the eye and of visual sensation.

The eye. The human eye is a registering optical instrument, like the camera. In fact, it is a camera, the sensitive plate being the retina, which differs indeed from the photographic plate in recovering after each exposure so as to be ready for another. Comparing the eye with the familiar camera, we find that the outer tough white coat of the eyeball, the sclerotic coat,

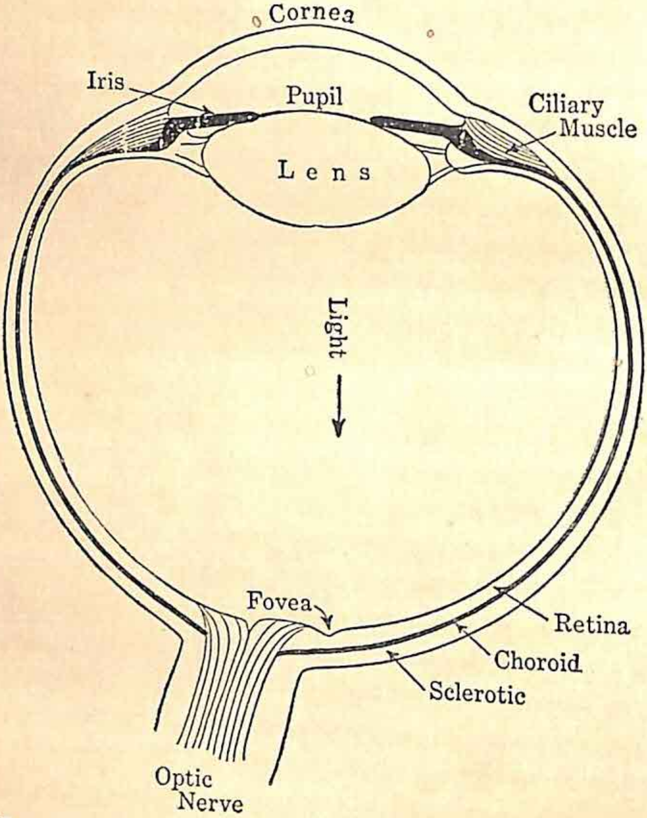


FIG. 71. — Horizontal cross section through the right eyeball.

takes the place of the wood or metal of which the camera box is made, while the black choroid coat, lining the sclerotic, corresponds to the coating of paint used to blacken the inside of the camera box and prevent stray light from entering and blurring the picture. At the front of the eye, where light is admitted,

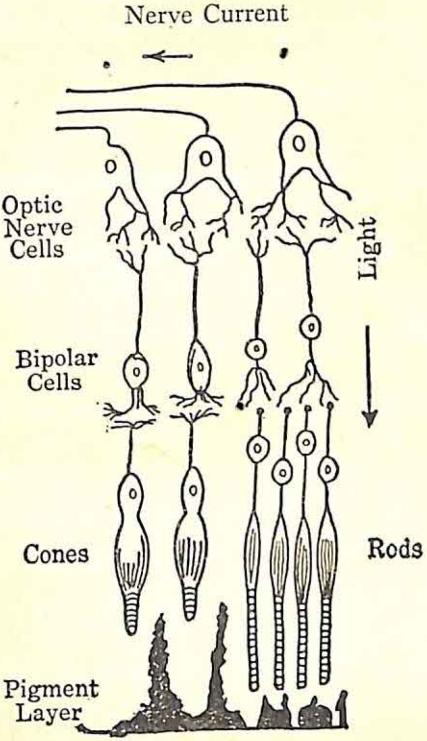


FIG. 72. — Sense cells and nerve cells of the retina. Light, reaching the retina from the interior of the eyeball (as shown in FIG. 71), passes through the nearly transparent retina till stopped by the pigment layer, and then and there arouses to activity the tips of the rods and cones. The rods and cones pass the impulse along to the bipolar cells and these in turn to the optic nerve cells, the fibers of which extend by way of the optic nerve to the interbrain. See p. 203.

the choroid gives place to the colored iris, with the hole in the center that we call the pupil of the eye. The iris has little muscle fibers in it, which regulate the size of the pupil; it corresponds to the adjustable diaphragm of the camera. The sclerotic gives place at the front of the eye to the curved, transparent cornea, which is a powerful lens. Just behind the pupil is another lens, adjustable in curvature by the action of the little ciliary muscle. This muscle corresponds to the focusing mechanism of the camera; by it the eye is focused on near or far objects. The aqueous humor (in front of this lens) and the vitreous humor (behind the lens) fill the eyeball and keep it taut and spherical, while still, being transparent, they allow light to pass through them to the retina. The retina is a thin membrane, lining the rear of the eyeball, and containing the sensitive cells.

The visual receptors. The retina contains sense cells of two forms, the rods and the cones. They are located at the back of the retina, next to the pigment layer. Probably the incoming light first produces some chemical and electrical change in the pigment, and this change stimulates the rods and cones.

The cones are more highly developed structures than the rods. At the fovea, a little depression in the retina, straight back from the pupil, only cones are present, and this is the "center of clear vision." In looking straight at a small object so as to see it distinctly, we turn the eyes so that the light from that object falls on the fovea. Outside of this little central region, rods and cones are intermingled, with fewer and fewer cones the further out in the retina you go. The further out you go, also, the less distinctly both form and color are seen, from which fact it is believed that both form and color vision depend mostly on the cones.

Rod and cone vision; adaptation of the retina to dim and strong light. The first, prompt reaction of the eye to change of illumination is a widening or narrowing of the pupil. But there is a slower and more effective change that occurs in the retina itself, and that amounts to a sensitizing of the retina to the degree of illumination. Go into a dark room, and at first all seems black, but by degrees, provided there is a little light filtering into the room, you begin to see, for your retina is becoming dark-adapted. Come out of the dark into a bright place, and at first you are "blinded," but you quickly get used to the bright light and see distinctly, your retina having become light-adapted.

Complete dark adaptation requires a stay in the dark of fully half an hour, and leaves the eye over a thousand times as sensitive to faint light as on first entering the dark from a well-lighted room.

While in the dark, after becoming dark-adapted, you will notice that you see only light and shade and no colors. Another significant fact is that the fovea, which has only cones and no rods, has the best color vision, but does not become well dark-adapted and is almost blind in very dim light. These facts are taken to mean that vision in dim light, or *twilight vision* as it is sometimes called, is rod vision and not cone vision. The rods become sensitized to very faint light, far outstripping the cones in this respect. On the other hand, not the rods, but only the cones, have color vision.

Stimulus and sensation in the sense of sight. Without going into the physics of light to any extent, we can say that light has so much of the vibratory character as to allow us to speak of its wave length. In the rainbow, or spectrum, light of the different wave lengths is separated and spread out in order before us. At the red end of the spectrum, the wave length of the light is 760 millionths of a millimeter, and at the violet end it is 390 millionths. In between are waves of every intermediate length, appearing to the eye as orange, yellow, green and blue, with all their transitional hues. A wave length of 600 gives yellow, one of 500 gives green, one of 470 gives blue, etc. Outside the limits of the visible spectrum, there are longer and shorter waves, incapable of arousing any sensations of light, though the long waves, beyond the red, excite the warmth sense of the skin, and the very short waves, beyond the violet, while arousing none of the senses, do tan the skin and produce other physiological effects.

Seldom does the light reaching the eye from any point consist of waves that are all of the same wave length. Sunlight contains waves from all parts of the spectrum and appears as white. The light from an electric bulb appears pale yellow because while containing waves from all parts of the spectrum it is relatively strongest in the middle wave lengths. Light that has passed through a sheet of good red glass comes out pure red because all but the red waves are strained out by the pigment in the glass. Thus light varies in amount of mixture of different wave lengths. Light varies also in intensity or energy.

The stimulus entering the eye from any point can vary, then, in three ways: in wave length, in energy, and in amount of mixture; and we now ask what difference in sensation corresponds to each of these differences in the stimulus.

To the energy or intensity of the stimulus corresponds the *brightness* of the visual sensation. The brightness series extends upwards from absolute darkness to an undefined maximum.

To the wave length of the stimulus corresponds the *color-tone* of the visual sensation. The color-tone series extends from red through yellow and the other colors of the spectrum to violet and then by way of the purples back to red again. It is a circular series.

To the mixture of wave lengths in the stimulus corresponds the *saturation* of the color sensation; the more mixture the less saturation. A full, pure color is saturated, a pale or dull color unsaturated. A saturated color need not be bright, and certainly a bright color need not be saturated. Pink and reddish brown are both unsaturated red; pale blue and bluish gray are alike in being unsaturated blue. A fully saturated color is one whose total brightness is accounted for by its color strength.

These are the general correspondences between the physical light and the visual sensation, but the whole relationship is much more complex. Brightness depends, not only on the energy of the stimulus, but also on its wave length. The retina is most sensitive to waves of medium length, corresponding to the yellow of the spectrum. A given amount of physical energy arouses a much stronger light sensation if its wave length is medium than if it belongs near the red or the blue end of the spectrum.

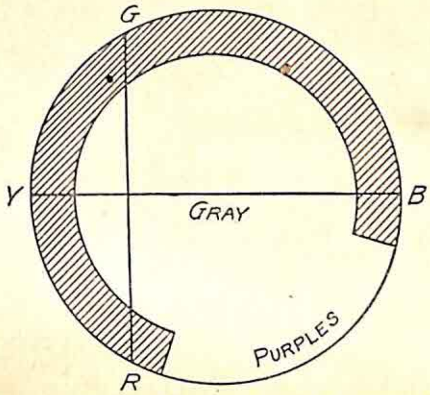


FIG. 73.—The color circle. *R*, *Y*, *G* and *B*, stand for the colors red, yellow, green and blue. The shaded portion corresponds to the spectrum or rainbow. Complementary colors (see later) lie diametrically opposite to each other on the circumference.

Color mixing. Color-tone, as has been said, depends on the wave length of the light stimulus, each color-tone being a response to one particular wave length. But this is not the whole truth. Any color-tone can be got without its particular wave length being present at all, by mixing wave lengths lying on both sides of this particular one. For example, the orange color given by wave length 650 is given also by mixing wave lengths 700 and 600; a mixture of red and yellow lights gives orange.

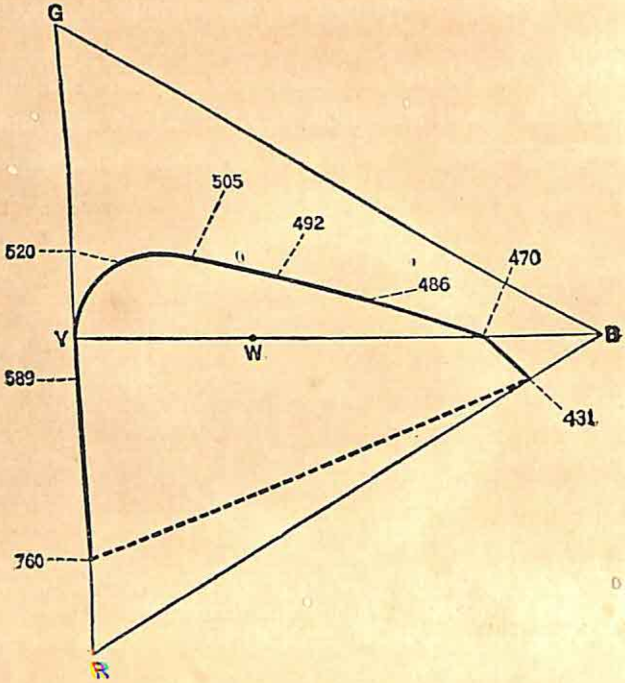


FIG. 74. — (After König.) The color triangle, a map of the laws of color mixture. The spectral colors are arranged in order along the heavy solid line, and the purples along the heavy dotted line; the numbers are wave lengths. Inside the heavy line are located the pale tints of each color, merging from every side into white, which is located at the point *W*.

Suppose equal amounts of two spectral colors are mixed: to find from the diagram the color of the mixture. Locate the two colors on the heavy line, draw a straight line between these two points, and the middle of this line gives the color-tone and saturation of the mixture. For example, mix red and yellow: then the resulting color is a saturated reddish yellow. Mix red (760) and green (505): the resulting yellow is non-saturated, since the straight line between these two points lies inside the figure. If the straight line joining two points passes through *W*, the colors located at the two points are complementary.

Spectral colors are themselves not completely saturated. The way to get color sensations of maximum saturation is first to stare at one color, so as to fatigue or adapt the eye for that color, and then to turn the eye upon the complementary color, which, under these conditions, appears fuller and richer than anything otherwise obtainable. The corners, *R*, *G* and *B*, denote colors of maximum saturation, and the whole of the triangle outside of the heavy line is reserved for supersaturated color sensations.

A point of experimental technique: in mixing colored lights for the purpose of studying the resulting sensations, we do not depend on mixing paints, but we throw both lights together into the eye or on a white screen. We can also, by virtue of a certain lag or hang-over in the responses of the retina, mix lights by use of the "*color wheel*," *which throws them in rapid alternation into the eye.*

By mixing black and white in different proportions we obtain the whole series of dead grays. By mixing white with any saturated color we make it paler and less saturated. By mixing black with any color we lower the brightness of that color. If we take a saturated green, and mix with it a little gray that has the same brightness as the green, we obtain a less saturated green of the same brightness as before; and if we mix more *and more of this gray with the* green we obtain a saturation series of uniform brightness, extending from the saturated green to greenish gray and finally to dead gray. A similar saturation series can be obtained by mixing gray with any saturated color.

By mixing red and yellow, in different proportions, we get all the color-tones intervening between red and yellow — all the oranges. By mixing yellow and green we get all the yellowish greens, and by mixing green and blue, all the greenish blues. Finally, by mixing blue and red, we get violet and the purples. Purple has no place in the spectrum, since it is a sensation which cannot be aroused by the action of any single wave length, but only by the mixture of long and short waves.

Now what happens if you add yellow to blue? Those who know about mixing paints will say that you will get green; but mixture of paints is decidedly not adding lights, for each paint *absorbs* or subtracts part of the light, and the effect of the double subtraction is very different from *adding* blue and yellow. If you add blue and yellow, you get white or gray. Two wave lengths which, when acting together on the retina, give a white or gray sensation, are called *complementary*. Yellow and blue, then, are complementary.

Red and green are sometimes said to be complementary, but such a statement is inaccurate, for if you take typical red and green, such as brick-red and grass-green, and mix them, you get a dull yellow, but never a white or dead gray. The complementary of red is bluish green, and that of green is purple.

Red and green, however, like blue and yellow, may be called a *disappearing color pair*. When you mix blue and yellow, both disappear, and you get the sensation of white, in which there is no resemblance to either yellow or blue. So, when you mix red and green, both disappear, and the sensation of yellow emerges.

Elementary, primary and salient color-tones. There are thousands and thousands of distinguishable colors, including all the shades and tints, and every one is simple or elementary in this respect, that you cannot actually *see* any other colors in it. You can speak of seeing red and yellow in orange, meaning that you see the resemblance of orange to both red and yellow, but as you look at the orange color you do not actually see a good red and a good yellow. The red and yellow are so perfectly blended in the orange as to lose their own specific qualities, and the orange has a specific quality all its own. In this respect all colors are equally elementary.

But some colors are more salient or outstanding than others. White and black are the clearest examples. They are the extremes in the white-black series of grays, and there is no gray in the series that stands out above the rest. If the color-tones are arranged in a circle, red, yellow, green and blue stand out and might well be made the corners of a square diagram which would be substituted for the circle. As you advance gradually from red to yellow, the orange becomes less and less red and more and more yellow, but as you pass yellow you see a new tone coming in, the green. In passing yellow you seem to be turning a corner — and the same at green, blue and red.

It would seem reasonable to conjecture that the salient colors are also primary and that all the other colors are derived from them by combination. That is, we may reasonably suppose that the retina has just a few primary activities which however can go on together in varying proportions and give numerous resultant effects. The search for primary colors has proved very fascinating to psychologists and sense physiologists — fascinating and productive of opposing theories.

The facts of color mixture suggest a very small number of primaries, since all the color-tones, and also white and gray, can be obtained by mixing four wave lengths corresponding to red, yellow, green and blue. Moreover, you do not need the yellow, since you can get it by mixing red and green. All the colors, including white, can be got by mixing red, green and blue. This striking fact is the basis of the well-known Young-Helmholtz (7) theory of color vision, which supposes that there are just three primary responses of the retina to light, and three primary color sensations, red, green and blue, all other colors, including white, being combinations of these three.

This theory does not do justice to the salient colors, yellow and especially white, in which no one pretends to find any trace of the supposed primaries, red, green and blue. While orange can be called a reddish yellow, and purple a reddish blue, no one would call yellow a reddish green, or white a reddish, greenish blue. Further objections to this theory are found in the facts of color-blindness, next to be considered.

Color-blindness. There are two kinds of color-blindness, total and partial. *Total color-blindness* amounts to rod vision, which gives light and dark, but none of the spectral colors. The outermost zone or ring of the retina, where cones are very scarce, is almost totally color-blind. Some individuals, very few, are totally color-blind over the whole retina, having apparently no cones but only rods; their vision is poor, as would be expected.

With regard to color theory, we learn from total color-blindness that colorless sensations are not necessarily combinations of red, green and blue, since they occur when those color responses are not in the individual's power. Rod vision is certainly more primitive than cone vision, and we thus get the suggestion that white-black-gray vision is more fundamental than red-yellow-green-blue vision.

Red-green blindness, though very uncommon among women, is present in three or four percent of men. It is not a disease, and is not associated with any other defect of eye or brain. Nor can it be cured or corrected by training. It is simply a hereditary peculiarity of the color sense, a reduced or simplified form. The red-green blind individual has the sensations of yellow and blue, along with white, black and the grays — but no red or green. What appears to the fully equipped eye as red or green appears to him as dull yellow, and what appears to the normal eye as greenish blue, violet and purple appears to him as dull blue. He has difficulty in picking strawberries, in obeying the traffic lights, and in selecting his neckties.

Now everyone is red-green blind in the intermediate zone of the retina, between the central region which has full color sense and the outermost zone which is almost totally color-blind. This statement can be checked by taking bits of various colors and moving them slowly from the very margin of the field of view towards the center, all the while keeping the eyes directed straight ahead. When the bits first become visible, at the margin of the field of view, they have no color other than gray, then they take on a blue or yellow tinge, and finally, near the center of vision, they acquire their red or green components and show in their "true" colors.

As to theory, again, we learn from red-green blindness that yellow, as a visual response, is not merely a compound of the *red and green responses. The yellow response is made by individuals who cannot make the red or the green response. Yellow must be a primary.*

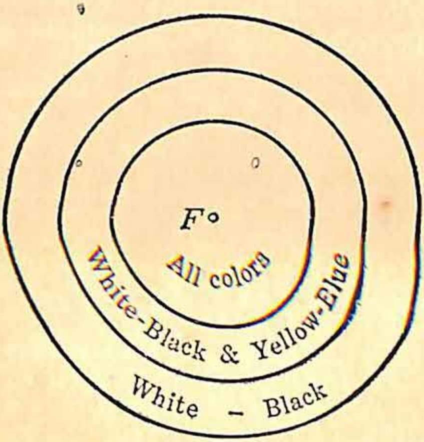


FIG. 75. — Color zones of the retina. *F* is the fovea, or central area of clearest vision. The zones are not actually so sharply separated as in the diagram.

Theory of color vision. Better than the Young-Helmholtz theory or than any other that has been sufficiently discussed, the Ladd-Franklin theory seems to sum up the facts (10). This theory treats of the color sense as having passed through three stages of development. In the earliest stage the only primaries were white and black; the second stage added yellow and blue; and the third stage, red and green. The outermost zone of the retina is still in the first stage, and the intermediate zone in the second, only the central retinal area having reached the final stage. In red-green blind individuals, the central area remains in the second stage, and in the totally color-blind the whole retina is still in the first stage. There is evidence that some animals normally remain in the first stage, and some in the second.

In the first stage, one response, white — in its various degrees of intensity, down to dark gray — was made to light of whatever wave length. In the second stage, this single response divided into two, one aroused by the long waves and the other by the short. The response to the long waves was the sensation of yellow, and that to the short waves the sensation of blue. In the third stage, the yellow response divided into one for the very longest waves, corresponding to red, and one for medium waves, corresponding to green. When, with an eye in the third stage, we mix red and green lights, the red and green disappear, and the old yellow takes their place. Similarly, when we try to arouse the yellow and blue responses together, they disappear and give place to the primitive white response out of which they developed.

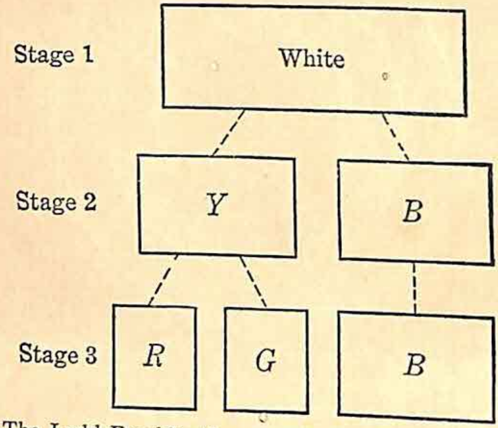


FIG. 76. — The Ladd-Franklin theory of the evolution of the color sense.

A word should be added about *black*. Black is sometimes said to be simply the absence of light. But black is as positive a sensation as any. We even speak of an "intense black." Black is a response made to the absence of light, but it occurs in its full intensity, as absolute black, only just after light is withdrawn from the eye, or else in an unlighted area surrounded by light.

After-images. A better name would be *after-sensations.*

Any response outlasts its stimulus. This is true of a muscle, and it is true of a sense organ. The ear is very quick in recovery, and gives almost no after-sensations, but touch after-sensations can easily be felt after a momentary touch on the skin. Visual after-sensations are the most interesting. If you look towards a lamp, but with a book in front of your eyes to serve as a screen, remove the screen for an instant and then replace it, you continue for a short time to see the light after the stimulus has been cut off. This *positive after-image* is like the main sensation, only weaker. There is also a *negative after-image,* best obtained by looking steadily at a black-and-white or colored figure for fifteen seconds, and then looking at a gray background. After a moment's delay, an after-sensation develops in which black takes the place of white and white of black, while for each color in the original the complementary color now appears.

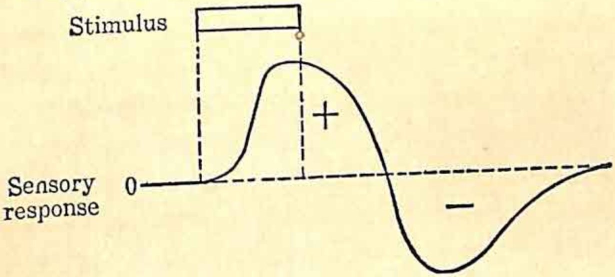


FIG. 77. — The visual response outlasts the stimulus. The progress of time is supposed to be from left to right in the diagram. After the stimulus ceases, the sensation persists for a time, at first as a positive after-image, and then as a negative after-image, a sort of back swing.

Visual contrast. Contrast is another effect that occurs in other senses, but most strikingly in vision. After looking at a bright surface, one of medium brightness appears dark, while this same medium brightness would seem bright after looking at a dark surface. After looking steadily at one color, and then turning the eyes upon the complementary color, the latter appears more saturated than usual; in fact, this is the way to secure the maximum saturation in color sensation. These are examples of "successive contrast."

"Simultaneous contrast" is peculiar to the sense of sight. If you take two pieces of the same gray paper, and place one on a black background and the other on white, the one on black looks much brighter than the other. Spots of gray on a colored background are tinged with the complementary color. Any two adjacent colors produce contrast effects in each other, though we do not usually notice them any more than we notice the after-images which surely occur many times in the course of a day. We disregard sensations that do not indicate objective facts.

The eye as a space and form sense. A really efficient instrument for registering the sun's radiation could not be allowed to respond only to a limited range of wave lengths, to be tuned selectively for the middle part of this range, to give the same response to various mixtures of wave lengths, or to show contrast effects. The eye can tell very little of the physical characteristics of any given light. What it does register, much more efficiently, is the spread-out-ness of light, shade and color in the field of view. The rods and cones are themselves spread out into a receiving screen upon which the lens system projects a sharp picture corresponding point for point with the field of view before the eyes. The form and spatial arrangement of objects in the field of view are reproduced in the retinal picture by the form and arrangement of colored patches, as in an oil painting. Do we see these patches of light and color, or do we see objects?

VISUAL PERCEPTION

Even in looking at an oil painting of a realistic sort, it is certainly much easier for the average adult to see the objects depicted than it is to see the patches and touches of color. It is easier to see object color than stimulus color.

Perception of object colors. If a white cow goes out of the sun into the shade of a tree, she does not seem to our eyes to change color. A black cow in the sun still looks black, though more light is reaching our eyes from her black surface than from the white surface of the other cow standing in the shade. To a remarkable degree we are able to identify the color of an object in spite of changes in the illumination. This fact is known by the name of "color constancy," meaning the constancy of object color as perceived (8, 11).

If you take two sheets of the same paper and place one near the light and the other far from the light, the latter is more dimly illuminated and consequently reflects less light to the eye, as you can easily verify by holding the near sheet so that it partly overlaps the farther one in your field of view. Nevertheless you have no difficulty in seeing that both sheets are of the same color as pieces of paper. This experiment has been tried out systematically on children and adults, who were asked to match various shades of gray, always matching a well lighted with a dimly lighted specimen. As the gray papers were alike in all other respects, they could be matched only by their shade. The matching was accomplished readily and with little error even by four-year-olds (2).

This ability to perceive object colors is not peculiar to man. Young hens were trained to pick grain only from the darker of two sheets of gray paper, which were kept under the same moderate illumination during the training period. When the habit of going always to the dark paper was well established, this darker paper was placed in direct sunlight, the other being placed near by but out of the sun. The hens still went to the darker paper, though now it was reflecting to their eyes much more light than the other (9).

Somewhat similar experiments have been tried with aquarium fishes which were found to be perfectly able to find the same-colored object in spite of wide differences in illumination (1).

There have been many variations of this color constancy experiment with human subjects. The constancy is seldom perfect, the usual match being a compromise between the stimulus color and the object color.

What object colors are, physically. A white object or substance is one that reflects all the light it receives, absorbing none, and a black substance is one that absorbs all and reflects none. (These are the "ideal" white and black; a good white paper does absorb some of the light, about 20%, reflecting 80%, and a good black paper reflects about 5% of the light.) A dead gray object absorbs some fraction of the light, and absorbs it unselectively, all wave lengths alike. A colored object is one that absorbs the light selectively, and therefore reflects selectively; a red object reflects the red rays predominantly, and a blue object the blue. The surface of any object is a light filter; a white surface sends all the light back unchanged; a black surface kills the light, and a gray partially deadens or darkens it; a red surface reddens the light; and so on. When we perceive object color, it is this physical property of the object which we perceive.

Taking account of the illumination. It is easy to prove that object color cannot be perceived unless the observer is enabled to allow for illumination. If the observer looks through a small window into a specially prepared room, in which all he can see is a disk of smooth paper, illuminated from a hidden source, this disk does not appear to him to be an object; it appears simply as a circle of light. If the room contains other visible objects standing in weak illumination, while the disk alone is receiving extra light from a hidden source, this disk now appears to be an object of a much lighter shade than it actually is; a near-black in strong concealed illumination is taken for a white disk. There are other ways of tricking the observer into a false perception of object color, and they all operate by giving him deceiving indications of the illumination.

From what has been said of the physical fact of object color, we see that the observer could arrive at that fact by deduction from two given facts, the illumination received by an object and the stimulus reflected by that object to the eye. If the observer saw the light reflected from the object to be the same in color and brightness as the illumination, he could infer that the object was white. If he saw the light reflected to be redder than the illumination, he could infer that the object was red. The observer does not actually go through any such process of reasoning and calculation; for he sees object colors instantly — actually *sees* them — provided the illumination is sufficiently revealed.

The set for illumination. There are several good indications of illumination: the general brightness and color of the field, the shadows and high lights, and the minute shadows and high lights on a rough surface. These are all seen in relation to the space characters of the visible field of objects. Under normal conditions the observer promptly becomes set or adjusted for the illumination, and consequently does not need to reason out the color of an object. He receives the stimuli from that object into an eye and brain which are set for the objective situation, illumination included. A camera can be set for high or low illumination, so as to register a given object the same in spite of differences of illumination. The adjustment of the human light-registering instrument occurs partly in the eye itself (size of pupil, retinal adaptation) but largely in the brain, as part of the total set for the situation.

Visual perception of object size and shape. A novice in drawing or painting from nature has the same difficulty with the shapes and relative sizes of objects as he has with their colors. He *sees* two men to be of the same height when one of them is standing ten feet from him and the other twenty feet; but if he makes them of the same size in his drawing, something is wrong. His teacher shows him how to measure the picture size of objects by holding his pencil vertically at arm's length and marking off the intercepted height of the object with his thumb; and he then finds that the man who stands farther away has much less height in the field of view and should be correspondingly diminished in the picture. Just as stimulus color depends on object color and illumination, so picture size or stimulus size depends on the real size of the object and on its distance from the observer; and just as the observer, when set for the illumination, can read the object color directly from the stimulus color, so, when set for the distance of the object, he reads off object size directly from stimulus size.

It is the same with the shape of objects. A novice seeing a circle draws it as a circle, while according to the stimulus received it is an ellipse unless it chances to be seen square on. In looking at a wall the observer sees its direction and sees the shape of a circle on that wall in accordance with this direction.

We have assumed in discussing the perception of object color, size and shape, that the individual can directly see the distance and spatial relations of objects. Before considering how this is possible, we need to take account of the facts of eye movement and of binocular vision.

Eye movements. The eyeball is turned in its socket by six little muscles, and the two eyes are so harnessed together in their motor nerve centers that they show almost perfect teamwork in their movements. They execute two types of coordinated movement. In looking here and there about the landscape, the two eyes turn together like a pair of horses, and this is the *conjugate* movement of the eyes. But in turning from a far to a near object, the eyes are brought from a parallel position into one of *convergence*, such that the foveas of both eyes receive the light from the particular object looked at.

The conjugate movement, on being recorded photographically (4), is found to have two varieties, called the jump or *saccadic* movement and the *pursuit* movement. The saccadic movement carries the eyes from one object to another, while the pursuit movement follows the same object as it moves. Watch the eye of someone who is looking at a scene and you will see them jumping from one part of the scene to another. The eyes fixate one point for a short time, jump to another point and remain there for a moment, and so on about the field of view. In reading, as the result of practice, the eyes follow a more regular procedure, fixating a series of points in a line of print, with short jumps from each fixation point to the next, and a longer reverse jump to the beginning of the next line. As each jump occupies but a thirtieth to a fiftieth of a second, while the fixation pauses between jumps last much longer, the result is that over 90 percent of the time spent on a line of print is fixation time, less than 10 percent being consumed in making the jumps. It has been found that nothing of any consequence is seen during the jumps, and that the real seeing takes place only during the fixations. The saccadic movement is simply a means of passing from one fixation to another with the least waste of time.

The eye sees an object distinctly only when at rest with respect to the object. If the object is still, the eye must be still. But if an object is moving with moderate speed, the eyes can keep pace by a pursuit movement, so remaining at rest upon the moving object, and getting a clear picture of that object, while the stationary background is a complete blur.

Binocular vision. In most animals, the eyes look to the side, and have different fields of view, and their combined fields compass almost the entire horizon. Though we can see the utility of this sort of binocular vision, it is difficult for us to imagine what it would be like, since the human eyes are located close together, looking forward, receiving almost the same stimulation, and functioning as a single organ. How does this type of binocular vision differ from monocular vision, and what advantage does it have?

First, the incoming currents from the two eyes reinforce each other in the brain, so that binocular vision is more impressive than monocular; it enables us to see slightly better and to respond somewhat more quickly. Still, the one-eyed individual is under no great handicap in these respects.

Second, two eyes are an advantage in near vision just because they then get *slightly different views* of the same object. The right eye sees a little more around to the right of a solid object held in the hands, and the left eye a little more around to the left. Thus the solid object is more completely seen at any one moment with two eyes.

Third, the brain responds to these slightly different simultaneous views of the same object, delivered by the two eyes, by not only seeing more of the solid object, but also by seeing the solidity of it, its third dimension.

Among man's special characteristics, which make his behavior different from that of animals, are the erect posture, freeing the hands for manipulation of objects, the development of the hand as a manipulatory organ, and the forward position of the eyes, which affords a three-dimensional view of objects as they are manipulated. Thus the human type of binocular vision fits in beautifully with man's manual dexterity and with his attentiveness to objects which can be handled. Binocular vision reveals the third dimension also in objects that are somewhat farther off, up to a hundred feet or more. But the eyes are so close together that they get essentially the same view of any distant object, so that the solidity effect of binocular vision disappears in the distance.

The *stereoscope* is a convenient instrument for experimenting upon binocular vision. It presents separate views to the two eyes. If the views show the same object or scene, photographed from two positions close together, the third dimension comes out very realistically. If radically different figures or colors are presented to the two eyes, by aid of the stereoscope, the usual result is *retinal rivalry*. First what is before one eye is seen for a time, then what is before the other, and so on alternately — as if the brain were unable to make any synthesis of the two discrepant images, and had to accept the one or the other at any moment. However, sometimes other results occur. A red before one eye and a yellow before the other may be seen as orange (binocular color mixture), and a bright red before one eye and bright green before the other are even combined into yellow — which creates a difficulty for the Ladd-Franklin theory of the color sense (6). The general principle seems to be that the brain uses the data from the two eyes the best way it can, with a bias towards objectivity.

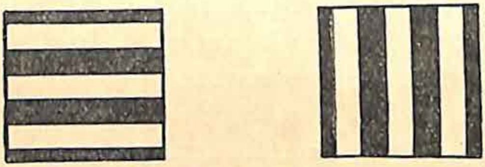


FIG. 78. — Binocular rivalry. Even without the aid of a stereoscope, different fields may be presented to the two eyes. Hold the figure close to the eyes, so that one half of it shall be before the right eye, and the other half before the left; and let the eyes relax and simply stare steadily, with no effort to see distinctly. If this is done right, the two squares will slide over each other so as to be superposed and seem to lie in the same place. Hold this position, staring steadily and passively, and observe whether there is any shifting from one set of bars to the other and back.

Seeing distance or the third dimension. The retina is a screen, and the stimuli received from the environment are spread out in two dimensions like a picture projected upon a screen. The picture has the left-right and up-down dimensions, but no front-back dimension. How then does it come about that we see the distance of objects from us, and the solidity and relief of objects? This problem in visual perception has received much attention and been carried to a satisfactory solution.

A single, motionless eye receives a picture similar to one painted on canvas, and the available indications of distance are the same in the two cases. The painter uses *perspective*, or foreshortening, and makes a man the smaller in the picture the farther away he wants him to appear; and in the same way, when any familiar object casts a small picture on the retina, we perceive the object, not as diminished in size, but as far away. The painter colors his near hills green, his distant ones blue, and washes out all detail in the latter — *aërial perspective*, he calls this. His distant hill peeks from behind his nearer one, being partially *covered* by it. His *shadows* fall in a way to indicate the relief of the landscape. These signs of distance also affect the single resting eye and are responded to by appropriate spatial perceptions.

With both eyes in use, we have the *binocular depth effect*, just described. This is a realistic appearance of solidity in three dimensions, provided the object examined is near. A little experiment demonstrates the superiority of binocular over monocular vision in the perception of distance. Take a pencil in each hand, close one eye and bring the pencil points horizontally from the two sides till they seem to be almost touching; then open the other eye, and see if you can improve the setting.

If the head is moved from side to side, while the eyes continue to look forward, distant objects seem to move with the head, and nearer objects to slide in the opposite direction. Try this in the woods some time, and see how clearly the nearer and farther branches are distinguished. If you look to the side from a rapidly moving train or car, the effect is still more pronounced.

All these signs of distance are utilized together in the visual perception of three-dimensional space, sometimes one sign and sometimes another being more useful. In learning the spatial meaning of these signs, the child is undoubtedly helped by watching objects as they approach or recede from him, or as he approaches them. The chick reacts correctly to distance as soon as hatched, and it is quite possible that some sign of distance, probably the binocular sign, does not have to be learned.

The several senses do not operate independently in perceiving spatial facts, for it is the organism as a unit that does the perceiving, utilizing the data from the senses as signs of objective facts, and cross-referencing the signs from different senses so that visual, auditory, cutaneous and kinesthetic space all agree. And the motor responses of eyes, head, hands and feet also fit into the system; the eyes and head turn towards a seen or heard object, and the hand reaches for it, all with great readiness and accuracy.

Erect vision in spite of the inversion of the retinal picture. The picture thrown upon the retina by the lens of the eye is upside down — a fact that formerly caused much fruitles speculation as to how, then, we can see the field of view rig side up. Stratton (12, 13) prepared a system of lenses that r inverted the field of view, and wore this device constantly for week, except at night when he was blindfolded. The lenses r versed right and left as well as up and down. The field o view was of course not distorted as a picture, and the eye an head movements of *looking towards a seen object* were n disturbed. But the relation of the visual field to hand, fo and body movements was reversed, with great resulting di turbance of movement and orientation. At first, movements i response to seen objects were entirely false; the subject reache in the wrong direction for any seen object, and ran into anything that he tried to avoid. Movements guided by the eye were laborious and nerve-racking, and had to be performed either by patient calculation or else by mere trial and error.

The situation in regard to movement was the same as in the mirror-drawing experiment (see p. 240), only more extreme; but as in mirror drawing the subject learns to guide his hands by the eye, so he did, more gradually, in this experiment with the completely reversed field of view. By the end of the week, the subject was able to walk freely about the house, and to perform all sorts of manual operations, and his behavior in familiar surroundings became almost normal, though the field of view still did not appear right side up. When he removed the lenses at the end of the week, the first effect was one of pleased surprise at finding himself back in his old, familiar visual space; but there was considerable bewilderment and movements were false again, since they continued to follow the new system of eye-hand coordination. After a few hours, however, the old system was fully reëstablished. Erect vision, according to the results, must be largely a matter of integration between vision and movement (5).

Seeing movement. Motion in the field of view is easily en, and fully as easily in indirect as in foveal vision. Part the utility of the external zones of the retina is their ready king up of any movement and arousing an eye jump which ings the fovea to bear on the moving object.

Motion pictures set an interesting problem in the perception f movement. What is projected on the screen is a series of ill pictures, a series of instantaneous snapshots, no single one which shows any motion. Whence comes the motion that u see in looking at this series of motionless views? Evidently e seen motion is your response. The film has enough in mmon with an actually present moving object to arouse the ame perception.

The lag of visual response, the positive after-image, plays a part here, for without it the picture would be seen to be intermittent, as it is physically. But a more important factor is that the brain is tuned to see motion, and grabs at any chance to see it. It sees motion much more readily than it can pick out the successive positions through which a moving body passes. Everyone who has examined snapshots has been surprised at the queer positions into which a man, or a horse, gets in the course of his movements. We can scarcely believe that he actually takes these positions. We perceive the movement as a continuous pattern, but we do not perceive the consecutive positions.

Apparent movement can be seen with much simpler stimuli than those of the moving pictures. All you need is two lines, a short distance apart, presented one after the other to the eyes with a little blank interval between them. You can try the experiment by simply holding the forefinger upright three or four inches in front of the nose, and looking at it while winking first one eye and then the other. To the right eye it appears more to one side and to the left eye more to the other side; and when one eye is closed and the other simultaneously opened, the finger seems actually to move from one position to the other. This result is confirmed by careful laboratory experiments. If the time interval between the exposures of the two lines is very short, the lines are seen as present together, each in its own position; and if the interval is rather long, one line is seen in its position and then the other in its position, without apparent motion. But if the interval is just right, movement appears (14).

Apparent movement can often not be distinguished from real movement, even when the observers are on their guard. When once the apparent movement has been seen, the observer becomes set for movement and readily sees it proceeding as before even when the stimuli are such as should give apparent movement in the opposite direction. This factor of set and expectancy must be an important factor in seeing meaningful movements such as those shown in the motion pictures; having become set for movement the observer all the more readily sees the movement continue. He receives the successive stimuli into a brain adjusted for continued movement (3).

Motion pictures are based on the proneness of the organism to see movement patterns rather than successions of discrete stimuli. They afford a striking example of the tendency to see objects and their behavior and not simply to see the light by which the objects are revealed.

REFERENCES

1. Burkamp, W. "Versuche über das Farbenwiederekennen der Fische." *Zt. Psychol.*, 1923, 55, Pt. 2, 133–170.

2. Burzlaff, W. "Methodologische Beiträge zum Problem der Farbenkonstanz." *Zt. Psychol.*, 1931, 119, 177–257.

3. De Silva, H. R. "An analysis of the visual perception of movement." *Brit. J. Psychol.*, 1929, 19, 269–305.

4. Dodge, R. "Five types of eye movement in the horizontal meridan plane of the field of regard." *Amer. J. Physiol.*, 1903, 8, 307–329.

5. Ewert, P. H. "A study of the effect of inverted retinal stimulation upon spatially coordinated behavior." *Genet. Psychol. Monog.*, 1930, 7, 177–363.

6. Hecht, S. "On the binocular fusion of colors and its relation to theories of color vision." *Proc. Nat. Acad. Sci.*, 1928, 14, 237–241.

7. *Helmholtz's treatise on physiological optics.* Edited by J. P. C. Southall, 3 vols. 1924–1925. esp. vol. 2, p. 426.

8. Katz, D. "Der Aufbau der Farbwelt." *Zt. Psychol., Ergänzumgsband*, 1930, 7.

9. Köhler, W. "Die Farbe der Sehdinge beim Schimpansen und beim Haushuhn." *Zt. Psychol.*, 1917, 77, 248–255.

10. Ladd-Franklin, C. *Colour and colour theories.* 1929.

11. MacLeod, R. B. "Experimental investigation of brightness constancy." *Arch. Psychol.*, 1932.

12. Stratton, G. M. "Some preliminary experiments on vision without inversion of the retinal image." *Psychol. Rev.*, 1896, 3, 611–617.

13. Stratton, G. M. "Vision without inversion of the retinal image." *Psychol. Rev.*, 1897, 4, 341–360; 463–481.

14. Wertheimer, M. "Untersuchungen zur Lehre von der Gestalt." *Psychol. Forsch.*, 1923, 4, 301–350.

CHAPTER XV

THE OTHER SENSES

Though sight is perhaps the most important of the senses to human beings, as well as the most thoroughly studied, there is much scientific information available regarding the other senses, and each of them has important contributions to make to the life of the individual and to his adjustment to the environment.

Problems in the study of the senses. As in the case of vision, the study of any sense includes two main problems: (a) the problem of sensation, i.e., of the correspondence of the individual's impressions with the *stimuli* he receives. The task is to arrange the multiplicity of sensory experiences in some kind of order, to identify salient and if possible primary sensations and to correlate them with their respective stimuli. (b) The problem of perception is that of discovering what use is made of each sense in knowing the environment; the question concerns the correspondence of the individual's impressions with *objects*.

The sense organs in general. The most primitive animals, the protozoa, though sensitive to various stimuli, are sensitive all over, rather than in certain spots. They respond to mechanical stimuli (contact or jarring), to certain chemical stimuli, to thermal stimuli (heat or cold), to electrical stimuli and to light. They have no special light-sensitive spot, but respond to light no matter where it strikes them.

In the development of the metazoa, or multicellular animals, specialization has occurred, some parts of the body becoming muscles, some parts becoming digestive organs, some parts conductors (the nerves) and some parts becoming specialized receptors or sense organs. A sense organ is a portion of the body that has very high sensitivity to some particular kind of stimulus. The eye responds to very minute amounts of energy in the form of light, but not in other forms; the ear responds to very minute amounts of energy in the form of sound vibrations, the nose to very minute quantities of chemical energy.

A useful classification of the senses divides them into the exteroceptors, the interoceptors, and the proprioceptors. The exteroceptors receive stimuli from outside the organism, the interoceptors from the interior of the mouth, throat, gullet, stomach, intestines and lungs, while the proprioceptors are located in the proper substance of the body, i.e., in the muscles, tendons, joints, bones, etc., and are stimulated by movements of these parts. Of the exteroceptors, the eye, ear and nose are singled out as *distance receptors,* because they receive stimuli from sources that are not in contact with the organism. The distance receptors enable the organism to adjust itself to a wide environment.

Mechanism of a sense organ. Each sense organ is a receiving instrument or indicator, as the thermometer is an indicator of temperature. The sensitive part of a sense organ is not visible from outside, but lies in the depth of the organ — that for smell being well back inside the nose and that for hearing being the inner ear, imbedded in the bone beneath the external ear. Each sense organ has its *sensory nerve* which connects it with the nerve centers and through them, indirectly, with all parts of the body. Without this nerve connection the sense organ could have no influence on the activities of the organism. The axons of the sensory nerve divide into fine branches within the sense organ, and the high sensitivity of the organ is partly due to these fine nerve endings. In addition, there are special *sense cells* in the eye, ear, nose and mouth. Besides these sensitive structures most of the sense organs contain *accessory apparatus* which conveys the stimulus effectively to the nerve endings and sense cells. The lens, the iris and the muscles of the eye belong in the category of accessory apparatus.

The excellence of a receptor depends (a) on its being *selective,* tuned to one kind of stimulus, and not indifferently responsive to every stimulus, (b) on its being very *sensitive* to its particular kind of stimulus, (c) on its responding differently to different *intensities* of the stimulus, and (d) on its responding differently to different qualities or *varieties* of the stimulus. For example, the sense of smell is selective in that it responds to odors and not also to sounds entering the nose — which would be confusing; it is sensitive in that it indicates the presence of incredibly small quantities of an odorous substance in the air; it responds differently to faint and strong odors by smell sensations of different intensities; and it gives different smells according to the odorous substance. Few man-made instruments can vie with the nose in these respects — or with the eye and ear.

THE SKIN SENSES

Rough and smooth, moist and dry, hot and cold, itching, tickling, pricking and stinging are skin sensations; but some of them are certainly complex. Relatively simple sensations are obtained by exploring the skin, point by point, with weak stimuli. As a cool stimulus, a pencil point at room temperature will serve for a hasty exploration. Passing it lightly along the skin, one gets at most points merely a sensation of contact, but at certain points there is a clear cold sensation. Within any half-inch square on the back of the hand, several of these *cold spots* can be found, and painstaking work, with adequate apparatus and procedure, shows some of them to be permanent. Similarly, *warmth spots* are located by using a stimulus a few degrees warmer than the skin. If a sharp point is pressed moderately against the skin, it gives at many places a small, sharp pain. These are the *pain spots*. Finally, if the skin is explored with a hair of just the right flexibility, nothing at all is felt in most places, but at some points there is a definite sensation of touch or contact; and these are the *touch spots*.

As no further varieties of sensory spots are found, touch, warmth, cold and pain are believed to be the only primary cutaneous sensations. Itch, stinging and aching seem to be variations of pain. Tickle seems to be a variety of touch.

Hard and soft combine touch from the skin with resistance encountered by the muscles and detected by the muscle sense. They are qualities of objects rather than of stimuli and are perceived rather than sensed. Somewhat the same is true of rough and smooth, which are felt by moving the skin over a surface and so obtaining a vibratory stimulus (9).

The hot sensation is interesting and curious. It is not simply a high degree of the warmth sensation, but is a combination of warmth and cold sensations (1, 3, 10). When a single cold spot is stimulated with a temperature of about 109° Fahrenheit, it responds with its regular sensation of cold. This cold sensation from a warm stimulus is called the "paradoxical cold sensation." The same temperature applied to a warmth spot gives the sensation of warmth. Now apply this same temperature simultaneously to both warmth spots and cold spots, located near together on the skin, and you get the sensation of heat. Or, you can get the hot sensation by simultaneously applying a cold stimulus to the cold spots and a warm stimulus to the warmth spots. If the temperature applied to the skin is quite high (about 117° F.), the pain spots also respond, and the pain sensation dominates. A very cold object also excites the pain spots and gives a sensation scarcely distinguishable from that of burning heat.

The elementary stimuli of the skin senses. The question is, exactly how the skin is acted on to give each primary sensation. In the case of *touch*, the exact stimulus is a bending of the skin, either in or out, at any touch spot, or at many touch spots at once. The stimulus that gives *pain* may be mechanical (as a needle prick), or thermal (heat or cold), or chemical (as a drop of acid), or electrical; but in any case it must be strong enough to injure or almost injure the skin. The pain receptors, then, are not highly sensitive, but require a fairly strong stimulus; their use is to detect the presence of stimuli that threaten injury.

Temperature stimuli require more discussion. The internal body temperature is steady, in health, at about 98° Fahrenheit, but the surface of the skin is likely to be about 85–90°, which feels neither warm nor cool, because neither the warmth nor the cold spots are aroused. They are "adapted" to skin temperature. Let a metal object, or other good conductor of heat, be laid upon the skin. If the metal object is warmer than the skin, it will raise the surface temperature. If the stimulus is a single degree above the skin temperature, it will feel warm — or cool, if a single degree below. Regarding the organism as a thermometer, we may say that its zero lies at skin temperature, and that its sensitiveness is very good for temperatures just above or below its zero.

This psychological zero shifts up and down according to the temperature of the skin. Immerse the hand for five minutes in water at any temperature between about 60° and 100° F., and you change the skin temperature and the zero point to correspond. Objects a degree or two warmer or cooler than the new zero will give the warm or cool sensation. Beyond the limits mentioned, the temperature sense cannot fully adapt itself (2).

There is an old and striking demonstration of temperature sense adaptation — a rougher form of the experiment just described. Take three bowls of water, one at skin temperature and seeming neither warm nor cold, one definitely hot and one definitely cold. Hold one hand in the hot water and the other in the cold, for half a minute, and then plunge them both into the medium water; and you will find the latter to feel warm to the cold-adapted hand and cold to the warm-adapted.

The organism as a thermometer gives more than the simple fact that an object is above or below skin temperature. With colder and colder objects, it gives increasing intensities of the cold sensation, till finally the pain sense is aroused. With objects above the psychological zero, it gives increasing intensities of the warmth sensation, then the sensation of heat, and finally pain. The whole scale, from painful cold to painful heat, covers of course only a small fraction of the range of physical temperatures.

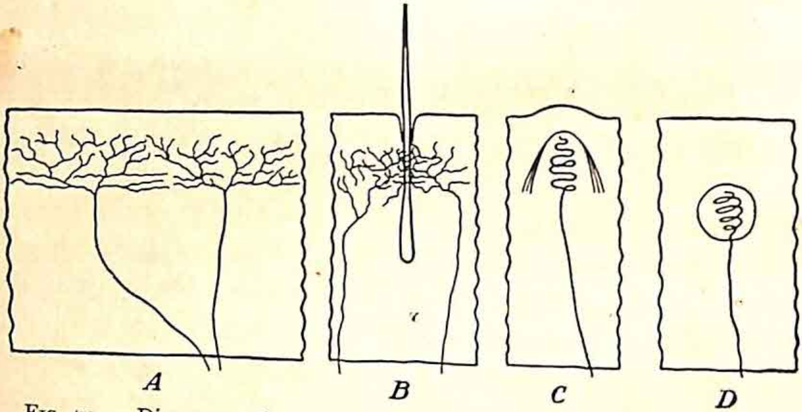


FIG. 79. — Diagrammatic views of skin receptors:
A, the most common type of skin receptor, present everywhere.
B, the hair receptor.
C, a touch corpuscle, from the finger tip.
D, an end-bulb, from the mucous membrane. There are several other varieties of end-bulbs found in the mucous membrane, in the surface of the eye-ball, in the subcutaneous tissue, etc.

The skin receptors. Innumerable sensory nerve fibers grow out from the nerve centers into the skin, where each one divides into many fine branches. Not in the outermost, horny layer of the skin, but just a little way in, is a perfect forest of fine nerve branches. On hairy parts, the hairs extend down into the forest of nerve ends in the skin and, when touched on the outside, act as little levers in stimulating the nerve ends. They are accessory apparatus to the sense of touch.

On hairless surfaces, especially the palms, some of the sensory nerve fibers terminate in little cones of tissue within the skin, and these "touch corpuscles" are believed to be touch receptors. Spherical end-bulbs, which are minute round or oval bodies, with a sensory nerve fiber terminating in each of them, are probably cold receptors.

Sensory nerve endings are present not only in the skin but also in the subcutaneous tissue, and deep pressure and dull pain can be felt even when the skin is anesthetized. Cutaneous sensation extends into the mouth and nose, and the tip of the tongue is a keen touch organ, but on the whole these extensions of the skin senses are less keen than the skin itself. As everybody knows, the skin is much keener in some parts than in others, and the four skin senses vary independently from place to place, one place being especially sensitive to cold, another to warmth, another to touch and another to pain stimuli.

THE MUSCLE SENSE

The muscle sense was the "sixth sense," so bitterly objected to in the middle of the nineteenth century by those who maintained that the five senses that were good enough for our fathers ought to be good enough for us, too. The question was whether the sense of touch did not account for all sensations of bodily movement. It was shown that there must be something besides the skin sense, because weights were better distinguished when "hefted" in the hand than when simply laid in the motionless palm, and because the coordinated movements of a limb were much more disturbed by loss of *all* its sensory nerves than by loss of its cutaneous nerves alone. Later, the crucial fact was established that sense organs (the "muscle spindles") existed in the muscles, and other sense organs in the tendons and about the joints. This sense is the muscle, tendon and joint sense rather than simply the muscle sense. It is sometimes called the *kinesthetic* sense, from the Greek words meaning "sense of movement."

The muscle sense is stimulated by muscular movements, by postures, by passive movements and by external resistance encountered in making any movement. It furnishes important information regarding the weight of objects, their firmness or

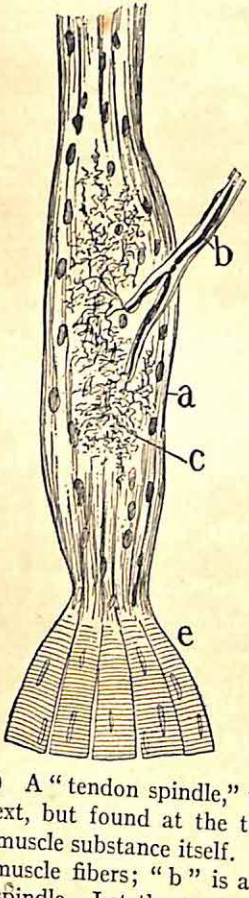


FIG. 80. — (From Cajal.) A "tendon spindle," very similar to the muscle spindle spoken of in the text, but found at the tendinous end of a muscle instead of imbedded in the muscle substance itself. "a" indicates the tendon, and "e" the ends of the muscle fibers; "b" is a nerve fiber, and "c" its ramified ending about the spindle. Let the tendon become taut in muscular contraction, and the fine branches of the nerve fiber will be squeezed and so stimulated.

looseness, hardness or softness, stiffness or flexibility. The muscle sense and the sense of touch work together in exploring the world by the hand.

The muscle sense is important in either reflex or voluntary movement. Without it, when you wanted to start any movement, you would have little indication of the existing position of the limbs; and when the movement was on the way, you would have little indication of how far it had progressed and would not know when to stop it. Locomotor ataxia, a disease characterized by unsteady posture and poor control of movement, is primarily a disease of the muscle sense nerves.

ORGANIC SENSATION

The term "organic sensation" is used to cover a variety of sensations from the internal organs, such as hunger, thirst, nausea, suffocation and less definite bodily sensations that color the emotional tone of any moment, contributing to "euphoria" and also to disagreeable states of mind. Hunger is a sensation aroused by the rubbing together of the stomach walls when the stomach, being ready for food, begins its churning movements. Systematic exploration of the internal organs reveals astonishingly few sensations arising there, but there can be little doubt that those just listed really arise where they seem to arise, in the interior of the trunk.

THE SENSE OF TASTE

A simple experiment shows that the numerous so-called tastes of daily life are not tastes in any exact sense. The subject holds his nose, so as to prevent any odor from reaching the olfactory receptors, and when thus limited to the sense of taste alone is unable to distinguish coffee from a weak solution of quinine, or apple juice from onion juice. Coffee and quinine have the bitter taste in common, and that is all the taste they have; onion and apple have the sweet taste in common. The primary tastes are limited to *bitter, sweet, sour and salty* (7).

The interior of the mouth is supplied with the skin senses as well as with taste. A biting "taste" is partly pain, and a smooth "taste" partly touch sensation. The temperature of a food or drink also contributes to what we inaccurately call its taste. In addition to all these sensations from the mouth, food in the mouth stimulates the sense of smell by way of the throat and the rear passage to the nose; and the *flavor* of food consists largely of odor.

Analysis of tastes, like that of skin sensations, is greatly assisted by the fact that the different sensations are aroused by stimulation of different spots. The papillae or little protuberances on the surface of the tongue contain the taste receptors, and correspond to the spots of the skin, with this difference, that few of the papillae give a single taste sensation. Some of them, however, give only two or three of the four primary tastes; and the bitter taste is got principally from the rear of the tongue, sweet from the tip, sour from the sides, and salty from the tip and the adjacent part of the sides. A sweetened bitter solution tastes sweet when applied with a little brush to the tip of the tongue, and bitter when applied to the rear of the tongue.

The actual taste receptors, called taste buds, are located not on the surface of the tongue, but in little pits which extend down from the surface. The taste buds are bunches of sense cells, each cell having a slender tip that projects into the pit, where it is exposed to the sugar or salt or other tasting substance present in the mouth. The sense cell, being thus aroused to activity, arouses in turn the fine branches of the sensory nerve fiber which twine around the base of the cell. Thus a nerve current is started along the sensory nerve to the brain.

The stimulus to the sense of taste is of a chemical nature. The tastable substance must be in solution in order to penetrate the pits and reach the sensitive tips of the taste cells. If the upper surface of the tongue is first dried, a dry lump of sugar or salt laid on it gives no sensation of taste until a little saliva has accumulated and dissolved some of the substance.

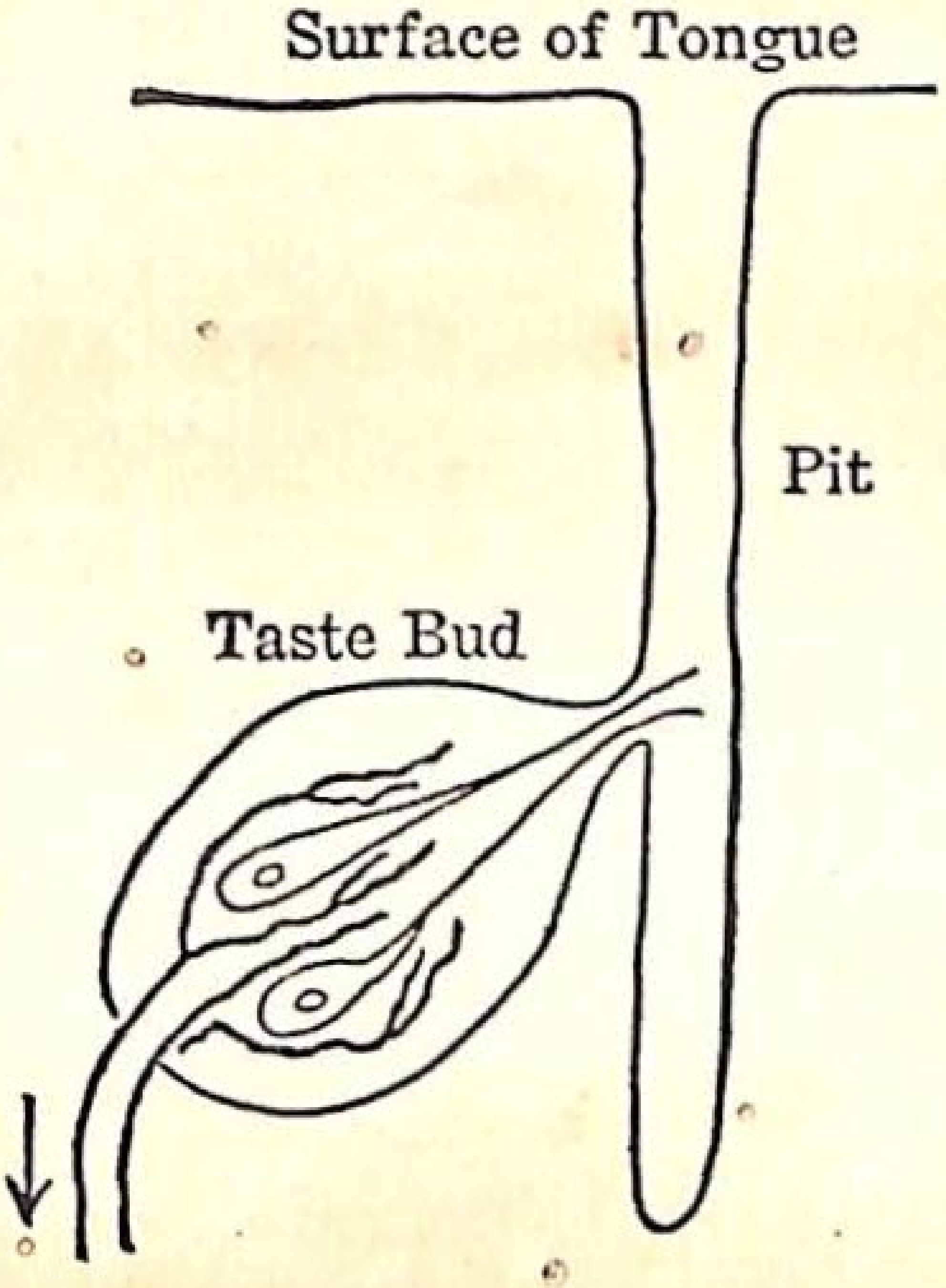


FIG. 81. — Diagram of the taste receptors. Within the taste bud are seen two sense cells with their connecting nerve fibers.

Exactly what the chemical agent is that produces a given taste sensation is a problem of some difficulty. Many different substances give the sensation of bitter, and the question is, what there is common to all these substances. The sweet taste is aroused not only by sugar, but also by glycerine, saccharine, and even "sugar of lead" (lead acetate). The sour taste is not aroused by all acids, and is aroused by some substances that are not chemically acids. The chemistry of taste stimuli is not yet fully understood.

Though there is this uncertainty regarding the stimulus, on the whole the sense of taste affords a fine example of success achieved by experimental methods in the analysis of complex sensations. At the same time it affords a fine example of the fusion of different sensations into characteristic *blends*. The numerous "tastes" of everyday life, though found on analysis to be compounded of taste, smell, touch, pain, temperature and muscle sensations, have the effect of units. The taste of lemonade, for example, compounded of sweet, sour, cold and lemon odor, has the effect of a single characteristic sensation. It can be analyzed, but ordinarily it appears as a unit.

THE SENSE OF SMELL

The great variety of odors has proved very difficult to reduce to order. The olfactory receptors are so secluded in their position, in a little alcove back in the nose, that they cannot be explored as the skin and tongue have been. The receptor cells are imbedded in the mucous membrane lining the nasal cavity and have fine tips which are exposed to the air in the cavity and so to chemical stimulation by odorous substances inhaled in the air.

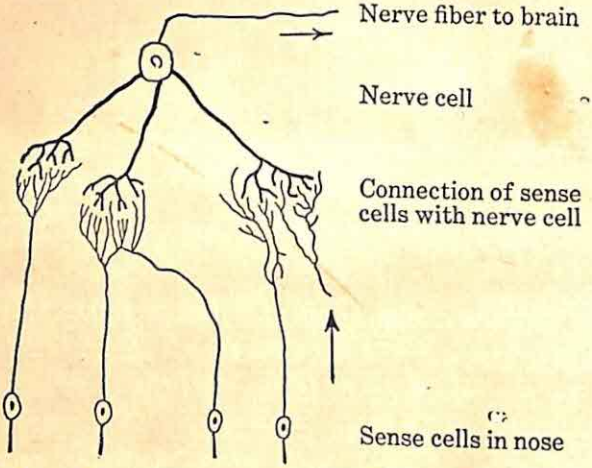


FIG. 82. — The olfactory sense cells and their brain connections.

Since we cannot apply stimuli to the separate receptors, about all that can be done in the way of analysis is to assemble a complete assortment of odors, and become thoroughly acquainted with their similarities and differences. Series can be arranged, grading off from one salient odor through intermediates to another salient odor. Recent work indicates about six salient odors, but whether these are true primaries or not is still uncertain. The following is Henning's classification, or list of the salient odors (6):

1. Spicy, found in cloves, cinnamon, etc.
2. Fragrant, found in heliotrope, vanilla, etc.
3. Etherial, found in orange oil, ether, etc.
4. Resinous, found in turpentine, pine needles, etc.
5. Putrid, found in hydrogen sulphide, etc.
6. Burned, found in tarry substances.

These being the outstanding odors, there are many intermediates. The odor of roasted coffee is intermediate between resinous and burned, that of peppermint between etherial and spicy.

The lower portion of the interior of the nose is supplied with the cutaneous senses, which are stimulated by many inhaled substances and contribute to what we call the "odor" of those substances. The "smell" of camphor or of menthol is partly cold sensation, and the "pungent odor" of ammonia, acetic acid, chlorine or iodine is partly pain.

The stimulus of the sense of smell is undoubtedly chemical, but the chemical correlations are not yet well worked out. It is an extremely sensitive sense, responding to very small quantities of certain substances diffused in the air. Other substances arouse no olfactory response at all. Many animals, such as the dog, make much more use than we do of this sense in exploring the world; but we probably use it more than we suspect.

THE SENSE OF HEARING

Sound is physically a wave motion or vibration in the air or other conducting medium. In the air, it consists in a slight back and forth motion of the air particles, a motion usually too slight to be felt by the sense of touch. The ear is much more sensitive, by virtue of its sense cells and accessory apparatus.

The sound-receiving apparatus of the ear. We speak of the outer, middle, and inner ear. The outer ear is a collector, the middle ear a transformer, and the inner ear the sensitive receptor. In man, the outer ear has little of the ear-trumpet action so beautifully shown by the donkey, and can be cut off with no noticeable effect upon hearing. Sound waves, entering the ear hole, strike the *tympanic membrane* within and set it into vibration. The membrane communicates its motion to the *ossicles*, an assembly of three little bones in the middle ear, and these concentrate the vibration upon a small opening from the middle to the inner ear. Thus the middle ear mechanism achieves the important result of setting into vibration the saline water that fills the inner ear.

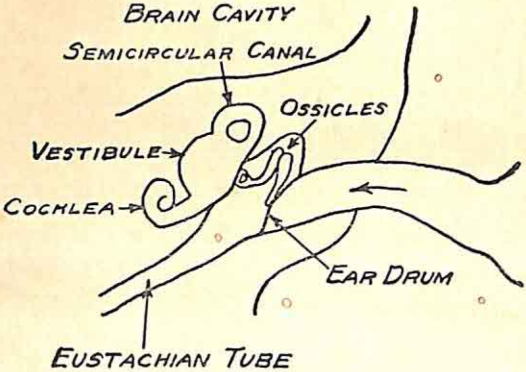


FIG. 83. — Diagram to show the parts of the ear, and the path of the sound waves from the outer through the middle into the inner ear. They start in as indicated by the arrow, and pass successively through the tympanic membrane or ear drum, the ossicles, the vestibule, the cochlea. The middle ear is filled with air, which comes in by way of the throat and the Eustachian tube.

The inner ear is first of all a cavity in one of the skull bones — a very small cavity, but complicated, with a *vestibule* in the middle, and with a spiral passage and also three *semicircular canals* opening out of the vestibule. The spiral passage, called the *cochlea* ("snail"), contains the auditory receptors. These are sense cells with delicate hair branches above, and with the fibers of the auditory nerve ramifying below. The sense cells rest on the *basilar membrane,* which is a fibrous ribbon stretched transversely between two shelves of bone and extending the length of the cochlea, widening from one end to the other, and as it widens becoming slacker and more heavily loaded by the overlying cells. These details agree in suggesting that one end of the basilar membrane is tuned to rapid sound vibrations and the remainder to slower and slower vibrations, like the strings of a harp or piano.

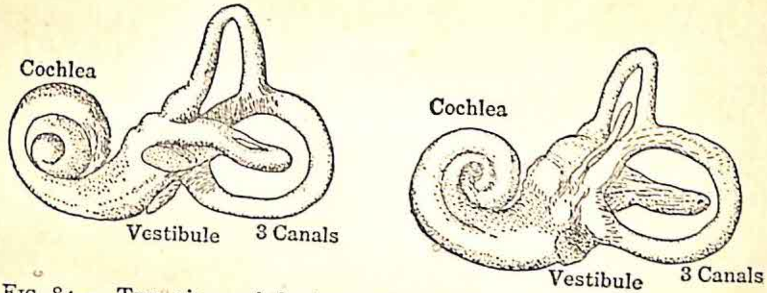


FIG. 84. — Two views of the internal ear. These views show the shape of the internal ear cavity. The sense organs lie inside this cavity. Notice how the three semicircular canals lie in three perpendicular planes.

Helmholtz's "piano theory" or resonance theory of hearing accepts this suggestion and supposes that each segment of the basilar membrane picks up the vibration rate to which it is tuned, out of the wave motion in the liquid filling the cochlea, is thrown into sympathetic vibration and thus shakes and stimulates the overlying hair cells which in turn stimulate the nerve fibers and start nerve currents on their way to the brain. The differential tuning of different parts of the membrane thus accounts for the individual's ability to distinguish sounds of different vibration rate, and to hear high, low and all intermediate tones (5, 13).

If a guinea pig is exposed, week in, week out, to a loud, steady tone of definite vibration rate, the result is that he becomes deaf to tones of that rate, and also, as shown by microscopic examination of his cochlea, that the hair cells on a portion of the basilar membrane degenerate (11, 14). A slowly vibrating tone, in these experiments, injures the hair cells on the wider part of the basilar membrane, while a rapidly vibrating (high) tone injures the cells on the narrower part of the membrane. These experiments support the piano theory of hearing, which however is not free from difficulties. An alternative theory regards the ear as analogous to a microphone or telephone receiver which is simply a transformer of vibrations from one medium into another — here from the liquid contents of the inner ear into the auditory nerve. By tapping the nerve cur-

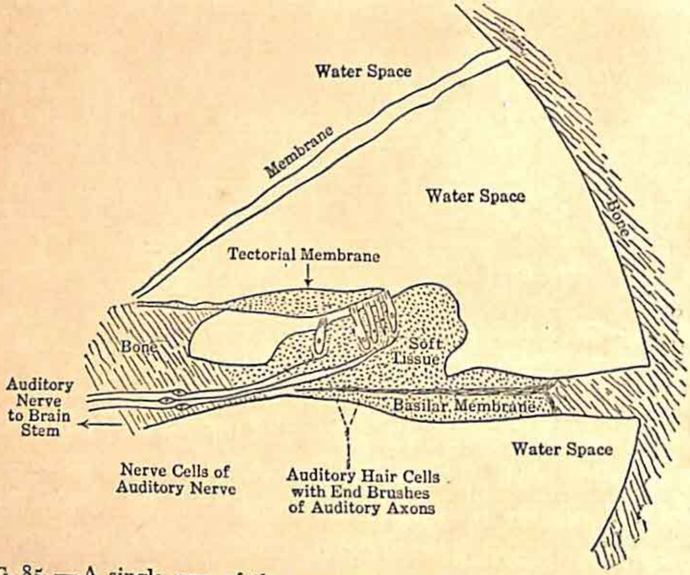

Water Space
Membrane
Water Space
Bone
Tectorial Membrane
Bone
Soft Tissue
Auditory Nerve to Brain Stem
Basilar Membrane
Water Space
Nerve Cells of Auditory Nerve
Auditory Hair Cells with End Brushes of Auditory Axons

FIG. 85. — A single row of the sense cells of the cochlea; there are about 5,000 such rows, standing on the basilar membrane. Each of the three "water spaces" is to be thought of as a cross section of a long slender tube. The sound waves come in from the middle ear and vestibule by the uppermost of the three tubes, and go through the membranes into the lowest tube which conducts them back to a vent into the middle ear.

rents and leading through amplifiers, investigators are seeking a decision between these rival theories (12).

Auditory sensations and their stimuli. An auditory sensation is the hearing of a sound, and is a response of the ear and brain to vibrations striking the ear. Heard sounds are roughly classified into tones and noises, tones being relatively smooth and steady, and noises mixed and irregular. Noise is produced by an unsteady medley of vibrations, tone by a sequence of uniform vibrations.

Heard sounds differ in loudness, in pitch and in timbre. By *pitch* is meant the highness or lowness of a tone. The soprano voice has a high pitch, the bass a low pitch. By *timbre* is meant the characteristic sound of different instruments and other sources of sound. A violin, a cornet and a human voice may all give the same note or pitch with the same loudness, but they can easily be distinguished by their timbre.

Now we must find three ways in which the vibratory stimulus can differ, to account for these three differences in the sounds heard. Air vibrations, if simple, differ in only two independent ways, in amplitude or extent of the back-and-forth swing, and in the frequency or rate of the swing, the number of vibrations per second. Compound vibrations differ also in composition.

Loudness depends on the amplitude of the vibration; the greater the amplitude the louder the sound. But loudness depends also on frequency of vibration, since (a) for a given amplitude a more rapid vibration delivers more energy per second to the ear, and (b) the ear is more sensitive to medium and fairly high vibration rates than it is to low rates. Pitch depends definitely and exclusively on the vibration rate; the higher the rate, the higher the pitch of the heard sound. Timbre depends on the composition of a complex vibration.

The deepest audible tones have a vibration rate of about 20 per second, and the highest a rate of about 20,000. Outside of these limits, there are plenty of physical sounds, but they arouse no auditory sensation. A giant organ pipe may emit vibrations at the rate of only 16 per second, and shake the whole auditorium, but these vibrations cannot be heard. A tiny whistle gives out 30,000, 50,000 or more vibrations per second, and these can be heard by some animals but not by the human ear. Individuals differ in their upper and lower pitch limits, and the upper limit declines gradually after the age of twenty (see Fig. 16, p. 64).

Though the ear is tuned to respond to this wide range of vibration rates, it is most sensitive to the middle part of this range, from 500 to 5,000 vibrations per second. Weaker vibrations can be heard at these middle rates than towards the extremes of the audible range.

Middle C of the piano, a note within the compass of all voices, though rather low for the soprano and rather high for the bass, has a vibration rate of about 260 per second. Go up an octave and you double the vibration rate; go down an octave and you halve the rate. The whole range of audible tones from 20 to 20,000 vibrations per second amounts to ten octaves, of which music employs about eight octaves, finding little esthetic value in the highest and lowest audible tones. The smallest step on the piano, called the semitone, is one-twelfth of an octave; but this is by no means the smallest pitch difference that can be perceived. Most people can distinguish tones that are four vibrations apart, and keen ears can detect a difference of less than one vibration; whereas the semitone, at middle C, is a step of about sixteen vibrations. The semitone is simply the smallest step utilized by the European scale, which came down from the Egyptians and Greeks. Oriental music uses different scales, and smaller steps than the semitone.

Combinations of tones — timbre. If two or more notes sound together, a chord or discord is produced. The esthetic value of the combination depends partly on the relative vibration rates of the component notes, partly on the hearer's being accustomed or not to this particular combination (a wholly unfamiliar combination being distasteful and a perfectly familiar combination being trite and uninteresting), and partly on the total pattern of successive chords in which the given combination occurs. The chord or discord is a blend, from which you can, to some extent, especially after practice, hear out the component notes. The auditory apparatus is to quite an extent an *analyzer,* making it possible to hear separate sounds out of a combination that simultaneously affects the ear. Thus, to take an obvious but important instance, you can hear what one person says to you through the din of other voices, street noises, etc. One sound does mask another to some extent, especially when both are of about the same pitch, but the degree to which you can hear out the separate sounds is remarkable, when the fact is considered that they are not separate in the air but enter the ear combined into one complex wave motion. According to the piano theory it is the ear itself which breaks up the compound wave into its component waves. If the parts of the basilar membrane are tuned to different vibration rates, then the parts corresponding to the vibration rates of a mixed sound entering the ear will respond separately, and so break up the complex wave into its elements. According to the telephone theory the analysis takes place in the brain.

Even a single voice, or a single note of an instrument, produces a combination of different vibration rates. Every sounding body gives off *overtones* along with its fundamental tone. The whole stimulus given off by middle C of the piano is a complex of fundamental and overtones, and the sensation aroused by this complex is a blend. We can, by careful attention and practice, hear out the overtones from the blend, but ordinarily we take the blend as a unit (just as we take the taste of lemonade as a unit), and simply get the characteristic quality of piano notes. Another instrument will give a different combination of overtones, and so a different blend, a different total quality. The timbre of an instrument depends on the particular combination of overtones which it gives out.

Speech sounds. These are perhaps the most important of all sounds for human beings to hear. The great handicap of the deaf child, which shows in his IQ, is probably his inability to hear what other people say. If we had time for a thorough study here, we should begin with the production of speech sounds by the vocal cords and by the mouth. Suffice it to say that the vocal cords supply the voice element in speech sounds

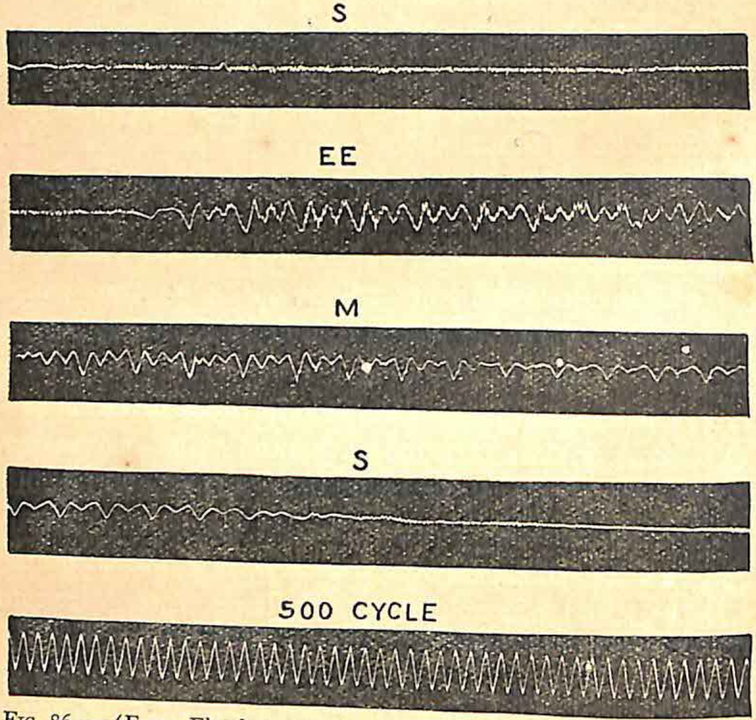


FIG. 86. — (From Fletcher, 4.) A record, obtained by the oscillograph, of the vibrations produced in speaking the word, "seems." The unvoiced *s* shows only rapid mouth vibrations. As *ee* begins, the vocal cord fundamental and overtones appear, with little superimposed mouth vibrations. The lowest line shows a simple tuning fork vibration at the rate of 500 per second.

— an element that is absent in whispering and in the "unvoiced" consonants, such as k, p, t, f, and s. The vocal cords produce overtones along with the fundamental tone that is being spoken or sung. But the vocal cords, by themselves, give no vowels or consonants. These are produced by the different positions of the mouth, tongue and lips. In any position, the throat, mouth and nose form a chamber that strengthens or dampens certain of the vocal cord overtones, and that also adds new, high tones to the vibration complex issuing from the mouth. These mouth and nose tones can be heard in whispering, when the vocal cords are silent.

Compare the mouth positions for sounding *o* as in "tone" and *ee* as in "teem." The tongue and lips take different positions in the two cases. The *o* position strengthens the vocal cord overtones and adds a mass of high but faint mouth tones. The *ee* position rather damps the vocal cord overtones, but adds a mass of strong, high mouth tones. Notice also the position for saying *s*: the tongue is brought up to the base of the upper teeth, leaving a narrow passage for the air, which whistles through, giving a mouth tone of very high vibration rate (about

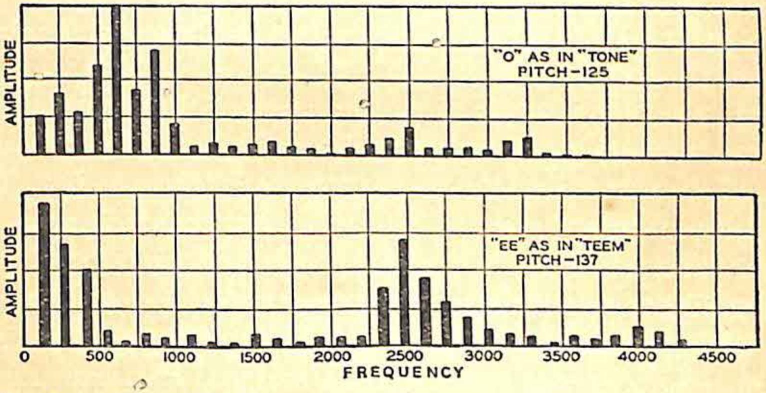


FIG. 87. — (From Fletcher, 4.) An analysis, made by an electric analyzer, of the component vibrations in the vowels *o* and *ee*. The location of the bars along the base line indicates the vibration rate of each component, while the height of each bar indicates the relative strength of each component.

7,500 per second), which can readily be heard in whispering the sound *s*. If you sound *z*, the corresponding voiced consonant, you can hear both the vocal cord tone and the hissing at the front of the mouth. You can feel them both, as well, in pronouncing this letter. Each speech sound is a different combination of tones. The development of telephone, phonograph and radio engineering has made it possible to obtain beautiful records and analyses of speech sounds.

In hearing speech, we do not hear out the component tones to any great extent, but recognize the total complex as a familiar blend. Even a whole syllable, composed of several speech sounds, is heard as a total pattern.

From the high pitch of many of the mouth tones that enable us to distinguish one vowel or consonant from another, we see how useful it is to have ears very sensitive to what might otherwise seem absurdly high vibration rates, from 2,000 to 5,000 per second, away above the range of the human voice, i.e., of its fundamental tones. These high mouth tones are weak in comparison with the vocal cord tones, and, as the sensitiveness of the ear to high tones decreases with age, one finds it more difficult to hear what people are saying, though one can still hear the rumble of their voices.

The elementary auditory sensations. Simple tones, free from overtones and noises, can be arranged in a continuous pitch series, from the lowest to the highest audible tones, with no breaks, " corners " or " salient sensations " such as we have found in the other senses. The notion of a few primary sensations, which was useful in understanding the cutaneous senses, sight, taste and possibly smell, has no value in the case of hearing. Every tone, provided it is a single tone, is as primary as any other. This continuous scale of auditory responses makes the ear a much better registering instrument for sound than the eye is for light. The ear registers the component vibrations of a chord much more adequately than the eye can do for a mixture of light rays. In compensation, the eye is far superior to the ear in registering space relations.

Localization of sounds. Such ability as we have to perceive the direction of the source of sound arises primarily from the fact of *binaural hearing*. A sound from the right side strikes the right ear with more force than the left, and strikes it a little sooner, and thus binaural hearing gives a definite right-left distinction. But it tells us nothing as to whether a sound comes from in front or behind, from above or below. By turning the head, however, we can obtain additional indications of the direction from which the sound is coming. Moreover, in familiar surroundings and with familiar sounds, we have learned to use various indirect indicators of the direction and even the distance of the sounding body. If we recognize the sound, its loudness indicates how far off its source must be. The blind, more than the seeing, utilize echo and resonance for indicating the location of walls that reflect sound. There are many such indirect and learned indications of the location of the source of a sound. But binaural hearing remains the fundamental indicator.

Recalling Stratton's experiment (p. 385) with the inverted field of view, we may query what would be the effect on sound localization of interchanging the sounds that enter the two ears. The experiment has been tried (15) by fitting a tube into each ear hole and carrying it over the head to end in a receiving horn close to the other ear. Thus each ear got the stimulus that would normally enter the other ear. The subject wore this instrument for an hour or two a day for two weeks, and then all day for three days. The first effect was a complete right-left reversal in the localization of sounds, with much tendency to front-back reversal as well. The creaking of a door would be heard from the right rear and a person would be seen entering the door at the left front. Finding a ticking clock, with eyes closed, was a baffling task, for the more one went towards it the more it receded. With the eyes closed, this reversed localization persisted throughout the experiment with little indication that it would yield to training. But when the eyes were open they tended to dominate the ears. Even from the start of the experiment, when an object was *seen* making a noise, as a horse walking in the street, the noise sometimes seemed to come from the seen object; the visual signs of location prevailed over the auditory. The visual cue at first had to be very clear in order to overbear the auditory, but as the experiment progressed, vision dominated more and more, and the visual localization remained even after an object had gone out of sight, so that the subject could be in a busy street and hear all the sounds as coming from their objectively true sources. When the instrument was finally removed, the switch back to normal localization was immediate and complete.

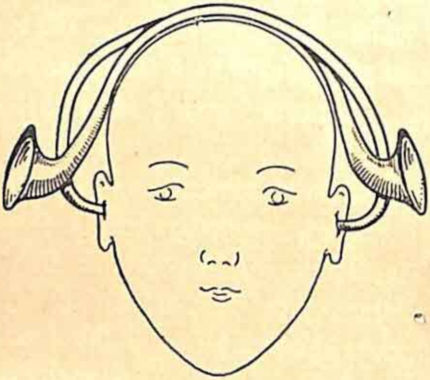


FIG. 88.—Diagram of Young's pseudophone. Each ear trumpet is continued by a tube that runs over the head and is plugged into the opposite ear.

THE SENSE OF HEAD POSITION AND MOVEMENT

It is a surprising fact that some parts of the inner ear are not connected with hearing at all. In fact, if we trace the ear back in the animal series, we find that its first use was to respond not to vibrations, but to movements and positions of the head. The cochlea is a recent addition to the ear, and so also are the middle and outer ear. The vestibule and the semicircular canals are the old parts, and they are more fundamentally important than hearing, because, being stimulated by positions and movements of the head, they provide the sensory data for the maintenance of posture, orientation with respect to gravity, equilibrium, and steadiness of movement. They enable the fish to keep right side up in the water, the bird in the air, the frog to right himself instantly if placed on his back, and the cat to land on her feet when falling from a tree.

There are receptors in the vestibule and semicircular canals, consisting of hair cells, somewhat similar to those in the cochlea. In the vestibule, the hair-tips of the sense cells are matted together, and in the mat are imbedded little particles of stone, the *otoliths*. When the head is inclined in any direction, these heavy particles sag and bend the hairs, so stimulating them; and the same result occurs, by inertia of the heavy particles, in any sudden starting or stopping of motion of the body. Around the base of the hair cells twine the fine terminations of sensory nerve fibers, which are excited by the activity of the sense cells, and pass the activity on to the brain.

Each semicircular canal has a bunch of hair cells, the long hairs sticking up into the water like reeds growing in a stream. Now, though the canals are called "semicircular," each is considerably more than a semicircle and, opening at each end into the vestibule, amounts to a complete circle. Rotating the head produces, by inertia of the water, a back flow in one or more of the canals, which bends the hairs and stimulates them. As the semicircular canals lie in three planes at right angles to each other, they provide a complete analyzer for head rotations in any direction. Meanwhile, the otolith receptors, which are also arranged in different planes, analyze the positions and rectilinear movements of the head. Thus the inner ear as a whole — quite apart from the cochlea — provides a complete analyzer for head positions and movements.

liancy, but it is heard as the same music though every separate tone has been changed. Hearing music is hearing a pattern of sounds rather than simply hearing sounds.

In listening to a person talk, there are four things we are hearing. We hear the sounds that reach our ears, the stimuli. We hear the person, the object emitting the sound, as in another case we hear an automobile. We hear words and sentences which are sound patterns. It may seem forced to say that we hear the speaker's meaning, but at any rate that is what we are trying to get. To penetrate behind the words to the meaning shows the same objective tendency in the listener as we have seen in numerous instances of going behind stimuli to their source in the environment.

REFERENCES

1. Burnett, N. C., and Dallenbach, K. M. "The experience of heat." *Amer. J. Psychol.*, 1927, 38, 418–431.

2. Culler, E. A. "Thermal discrimination and Weber's law. . . ." *Arch. Psychol.*, 1926.

3. Ferrall, S. C., and Dallenbach, K. M. "The analysis and synthesis of burning heat." *Amer. J. Psychol.*, 1930, 42, 72–82.

4. Fletcher, H. *Speech and hearing.* 1929.

5. Hartridge, H., and Banister, H. "Hearing." *Found. Exper. Psychol.*, 1925, 315–349.

6. Henning, H. *Der Geruch.* 1924.

7. Henning, H. "Psychologische Studien am Geschmacksinn." *Handbk. biol. Arbeitsmeth.*, 1927, 6, 627–740.

8. Katz, D. *Der Aufbau der Tastwelt.* 1925.

9. Katz, D. *The vibratory sense.* 1930.

10. Lowenstein, E., and Dallenbach, K. M. "Critical temperatures for heat and for burning heat." *Amer. J. Psychol.*, 1930, 42, 423–428.

11. Upton, M. "Functional disturbances of hearing in guinea pigs after long exposure to an intense tone." *J. Gen. Psychol.*, 1929, 2, 397–411.

12. Wever, E. G., and Bray, C. W. "The nature of acoustic response." *J. Exper. Psychol.*, 1930, 13, 373–387.

13. Wilkinson, G., and Gray, A. A. *The mechanism of the cochlea.* 1924.

14. Yoshii, U. "Experimentelle Untersuchungen über die Schädigung des Gehörorgans durch Schalleinwirkung." *Zt. Ohrenhk.*, 1909, 58, 201–250.

15. Young, P. T. "Auditory localization with acoustical transposition of the ears." *J. Exper. Psychol.*, 1928, 11, 399–429.

CHAPTER XVI

OBSERVATION

To judge from the complaints which the psychologist hears from those who consult him about their difficulties, people worry more about poor memory than about poor powers of observation. In studying memory, however, we came to the conclusion that poor memory meant poor learning rather than poor retention, and that the best learning consisted in noticing relationships, patterns and meanings and thus amounted to learning by observation. The individual who complains of poor memory must therefore, in most cases, be hampered by poor observation.

There are two steps in observation, which may be called *attention* and *perception*. Attention is preparatory to perception. Attention brings the observer into the presence of a fact, and perception consists in his grasping or knowing the fact. Attention explores, perception discovers. Columbus, first exploring westward, then discovering America, shows on a grand scale the same steps that are present in miniature whenever we first look towards something that has caught our eye and then see what is there.

ATTENTION

It is possible to perceive objects, rather vaguely, without attending to them, as when one who is absorbed in thought keeps enough track of his surroundings to avoid the ordinary dangers of the street; and it is possible to attend to something thought of and not perceived at the moment. But when we attend to a present object we are at least starting to perceive it. To attend to anything present without taking cognizance of it and without perceiving something of it would seem to be impossible. For that reason any experiment on attention is almost sure to be at the same time an experiment on perception. The topics are almost necessarily treated together.

Attending as a set or readiness. When the military officer shouts "Attention!" or when the athletic starter calls out "Ready!" the command puts the parties concerned in an attitude of readiness for what is coming next. It arouses in the individual a set which shuts out miscellaneous stimuli and responses, and clears the decks for what the officer or starter is going to say next. This preparatory set or readiness is the essential response in attending.

Attending as a motor adjustment. Two sorts of motor reaction occur in attention: the general attentive attitude, and the special adjustments of the sense organs. An audience absorbed in a speech or musical performance gives a good picture of the general *attentive attitude*. You notice that most people look fixedly towards the speaker, and that many of them lean forward as if it were important to get just as close as possible. All the little restless movements cease, so that you could "hear a pin drop," and at the tensest moments even the breath is checked. The attitude of attention is one of immobility, with the whole body oriented towards the object of attention. When the object of attention is something not present but thought of, a somewhat similar rigid attitude is assumed; the body is apt to lean forward, the neck to be held stiff, and the eyes to stare at vacancy, i.e., to be fixed on some convenient object as a mere resting place, while attention is fixed outside the visual field altogether.

But the motor response of attention includes more than the immobile attitude of readiness; it includes also responses of a mobile and shifting type. The exploratory character of attention shows itself in *sense organ adjustments*, which enable the individual to get more adequate stimuli from the object that has aroused attention. Attention to an object in the hand is shown by feeling of it, to something in the mouth by tasting movements, to an odor by sniffing movements, to a sound by a horse's pricking up his ears or by a man's cocking his head and turning his eyes towards the source of sound. The eye is focussed on the object by the action of the ciliary muscle adjusting the lens to the distance, and the two eyes are converged upon the object, so that the light from it strikes both foveas. If the object is in motion the eyes follow it, and if it is still they jump to it and fixate it.

Attention as the vivid center of an experience. We are more vividly conscious of that to which we are attending than of anything else. Of two objects before us, we are more conscious of the one to which we are attending; of two acts performed simultaneously that one is done more consciously to which we give our attention.

We are dimly aware of objects or acts to which we are not attending. Suppose, for example, you are looking out of the window while lost in thought. The matter of your thoughts is most vividly present to you, but you are aware to a smaller degree of objects out of the window, and more aware of the particular object on which your eyes are resting than of the objects seen in indirect vision. The vividness of the experience shades off from high light to dim background.

The "field of attention" is the high light of the momentary experience; it comprises the object under attentive observation, the reaction attentively performed. The "field of consciousness" includes the field of attention and much besides. It includes objects of which we are vaguely aware, cutaneous and kinesthetic sensations from various parts of the body, desires active but not clearly formulated, feelings of pleasantness or unpleasantness, of tension, excitement, confidence, etc.

Apparently the field of consciousness shades off gradually into the field of unconscious activity. Some physiological processes go on unconsciously, and very habitual movements may be almost or entirely unconscious. The boundary between what is vaguely conscious and what is entirely unconscious is necessarily very vague itself, but the probability is that the field of consciousness is broader than we suspect, and includes many activities that we think of as unconscious.

Vividness does not always tally with intensity of sensation or energy of muscular action. One may be more vividly conscious of a slight but significant sound — like the faint cry of the baby upstairs — than of much louder noises occurring at the same time. One may be more conscious of a delicate finger movement than of a big movement like walking.

It is not always the most efficient process that is most conscious; indeed, practicing an act makes it both more efficient and less conscious. The less efficient processes require attention because they tend to go wrong.

Evidently vividness does not go with bigness of total performance. When the organism is executing two performances at once, the smaller of the two may be the more conscious. How can this be? Probably vividness goes with brain activity, rather than with activity elsewhere in the organism, and probably executing a precise finger movement occupies the brain more than walking does.

SELECTIVITY

It is characteristic of the organism to have at its command a plurality of possible responses, some of which are antagonistic to others, as the avoidance response is antagonistic to the approaching response. It is further characteristic of the organism not to undertake two antagonistic responses at the same time. A bright light in one part of the field of view attracts the eye in its direction, say to the right, while another bright object attracts the eye simultaneously in another direction, say upwards. According to the parallelogram of forces which holds good of inanimate bodies, the eye should move along the resultant of these two attractions, obliquely upward and to the right. But what the eye does is to move *either* to the right *or* upward. The response is selective, and selectivity of response is so fundamental as to appear clearly in unicellular organisms or in the spinal reflexes of dogs and cats. It appears with equal clearness in the responses of attending and perceiving.

Along with this law of selectivity goes a law of *advantage* or prepotency. Although two or more alternative responses are within the power of the organism, one is apt to have the advantage and to be more readily aroused. Protective responses have the right of way in competition with digestive activity, as we saw in considering the organic response in fear and anger.

To these two laws of organismic activity can be added a third, the law of *shifting:* the response that has the initial advantage is likely to give way after a period of activity to some one of the alternative responses, provided the stimulating situation remains the same. If the two bright spots remain in the field of view, the eye, after fixating the one which had initially the stronger pull, shifts to the other.

Yet a fourth law, that of *combination,* should be brought in here as a counterpoise to the law of selectivity. To say that the organism responds selectively is not to say that it responds to single isolated stimuli; for it is often true that a combination of stimuli arouses a unitary response. This law holds good along with the others in the field of observational activity.

Factors of advantage in attracting attention. Among the numerous objects present in almost any situation, each of which may be assumed to exert some pull, certain objects will have more attraction than others, because possessing one or more of these factors of advantage.

Change is the greatest factor of advantage for gaining at least momentary attention. A steady noise ceases after a while to be noticed, but let it change in any respect and immediately it arrests attention. We become adapted to the steady clicking of the clock, but "wake up" with a start if it stops. This is a sudden change, and any change must have a degree of suddenness in order to attract attention.

Strength of the stimulus is another important factor of advantage. Other things being equal, a strong stimulus will attract attention before a weak one. A loud noise has the advantage over a low murmur, and a bright flash of light over a faint twinkle.

In the case of visible objects, *size* has about the same effect as intensity. The large features of the landscape are noticed before the little details.

Repetition is a similar factor. Repeat a cry or call several times, and after a while it may be noticed, though not at first. Repeat a "motive" in the decoration of a building, and it becomes more impressive than if used only once. The summation of stimuli has much the same effect as increasing the intensity of a single stimulus.

If, however, a stimulus is repeated or continued for a long time, it ceases to hold the attention, because of its monotony. It yields its hold on attention to some other stimulus having the advantage of change and novelty.

Striking quality is an advantage, quite apart from the matter of physical intensity. Saturated colors, though having less intensity of light than pale colors, are stronger stimuli for attention. High notes are more arresting than low. Itch, tickle and pain get attention in preference to a broad, smooth touch. What shall be striking and impressive depends on the organism, and cannot be defined in purely physical terms.

The factors of advantage so far mentioned do not depend on previous learning, but stand for natural or " unconditioned " stimuli for attention. There are other factors of advantage that do depend on previous learning and experience. The individual learns what is worth noticing and what is not, and thus forms habits of attention and of inattention. The automobile driver learns to attend to the sound of his motor, because it indicates whether the motor is laboring or missing or running nicely. The botanist becomes attentive to such very inconspicuous objects as the lichens on the tree trunks. Everyone learns *not* to notice repeated stimuli that are unimportant for him — an instance of negative adaptation (p. 236).

The direction of attention is often determined by the influence of other people. What the child shall notice depends largely on what is pointed out to him, and he becomes acquainted with the same things that other people know. Thus social influences standardize or regularize the knowledge which each individual acquires of the world.

Besides the natural factors of advantage, and besides the factors that depend on previous learning and experience, there are still other factors dependent on the momentary condition of the individual and on the activity he has in progress. Stimuli in line with the momentary interest catch attention more than they would at other times, while stimuli out of line with that interest escape attention. What you shall notice in the store window depends on what you are looking for as well as on the prominence of the different objects in the total display. When you are angry or disgusted with a person, you notice bad points that do not usually impress you. The desire or interest of the moment motivates attention.

The interest of the moment is often represented by a question in your mind. Ask yourself what spots of red there are visible, and immediately various red bits jump out and strike the eye; ask yourself what pressure sensations you are getting from the skin, and immediately several obtrude themselves. A question adjusts attention for whatever may furnish an answer.

The psychology of attention is of practical concern to the advertiser. Street signs quite obviously use the various factors of advantage. Illuminated signs bid for attention by strength of stimulus, and signs that flash on and off use change and repetition. Striking color is often in evidence, and the big signs outbid the little ones. Newspaper and magazine advertisements, in competing for the reader's attention, struggle to utilize all possible factors of advantage. Psychological experiments have shown that doubling the size of an advertisement falls short of doubling the number of readers whose attention it will catch, though it does increase that number considerably (by 40 or 50 percent); also that repeating an advertisement increases its attention value, especially if a certain amount of variation is combined with the repetition, to avoid monotony. More important, perhaps, than these mechanical devices is the appeal to habitual or temporary interests of the reader. If one is hunting for a job, even a little "want ad," with all the factors of advantage against it, except the factor of momentary interest, will surely catch the eye (1, 8).

Factors of advantage in perception. Perception as well as attention is a selective activity; at no one moment does it get all there is to be seen. It is distinctly subject to the law of combination, since it sees groups more easily than isolated details. And it is subject to the law of advantage, since some objects or facts are more easily perceived than others. Some of the factors of advantage in perception are well brought out in the examination of little drawings and designs.

1. *Proximity* of elements favors uniting them into a pattern. This can be seen in irregular dot figures: the groups most easily seen consist of dots that are relatively close together.

2. *Similarity* of elements favors uniting them into a pattern.

The same dot figure that showed groups dependent on proximity falls into a different grouping if some of the dots are given a different shape, or color, from the rest, for the similar dots tend to be seen as a group, and two interlacing groups may thus appear.

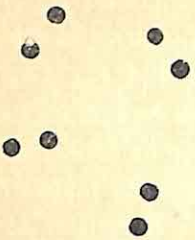


FIG. 90.

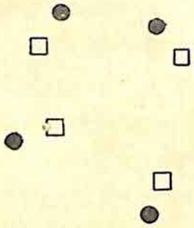


FIG. 91.

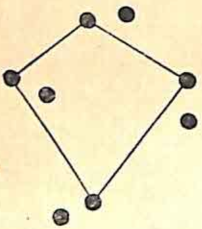


FIG. 92.

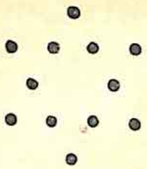


FIG. 93.

FIG. 90. — A dot figure to show proximity as a factor of advantage in seeing figures.

FIG. 91. — A dot figure to show similarity as a factor of advantage in seeing figures.

FIG. 92. — A dot figure to show continuity as a factor of advantage in seeing figures.

FIG. 93. — A dot figure to show inclusiveness as a factor of advantage in seeing figures. This figure contains two hexagons, and also two interlacing triangles, all good figures which may show themselves from time to time, but which are at a disadvantage in competition with the all-including star.

3. *Continuity* of pattern is a factor of advantage. Continuity may be lugged in by faint lines tying certain of the dots together, or it may be provided by the arrangement of the dots themselves.

4. *Inclusiveness* of a pattern is a factor in its favor, as against other patterns which would otherwise have the advantage. If

all the elements fall readily into a single group, that pattern has the advantage; if they do not, the pattern consists of two or more groups, or of a group with stragglers left outside (6, 13).

A critical reader, remembering all that can be accomplished by learning and "conditioning," and disposed to minimize the unlearned element in behavior, may well raise the question whether the laws of perception thus far stated are really primary. He may suggest, for example, that dots when close together are seen as belonging together, just because long continued experience has familiarized us with innumerable small, compact objects, the parts of which we have found to belong together. But such a view is vague, and can scarcely hold of extreme cases. To ask us to believe that two points lying far apart in the field of view could just as easily be grouped together as two points lying close to each other — or to ask us to believe that two drum beats separated by half a minute in time could just as easily be grouped as two coming only a second apart — is asking a little too much. While much needs to be done in the genetic study of perception, we may take it as probable that there are a few fundamental characteristics of perception, which are not drilled into us by learning. The fundamental characteristic of all is that groups, patterns and figures are more readily perceived than separate elements. Perception is a combining activity, as well as selective.

In order, however, not to neglect the importance of previous learning in perception, let us add another to our factors of advantage, namely that:

5. *Familiarity* of a pattern or object gives it the advantage over others that are less familiar. Picking out a circle or a human profile from a mass of lines is made easier by the familiarity of these figures. We should also add that:

6. The *set* or *readiness* of any moment is a factor in determining what shall be perceived at that moment. If you are set to see a certain pattern or object, or to hear a certain rhythm,

that pattern has the advantage over others equally familiar or compact.

Puzzle pictures prove that familiarity and readiness are not the *only* factors operating, since often you simply cannot find the hidden face, though you are set for faces, and though faces

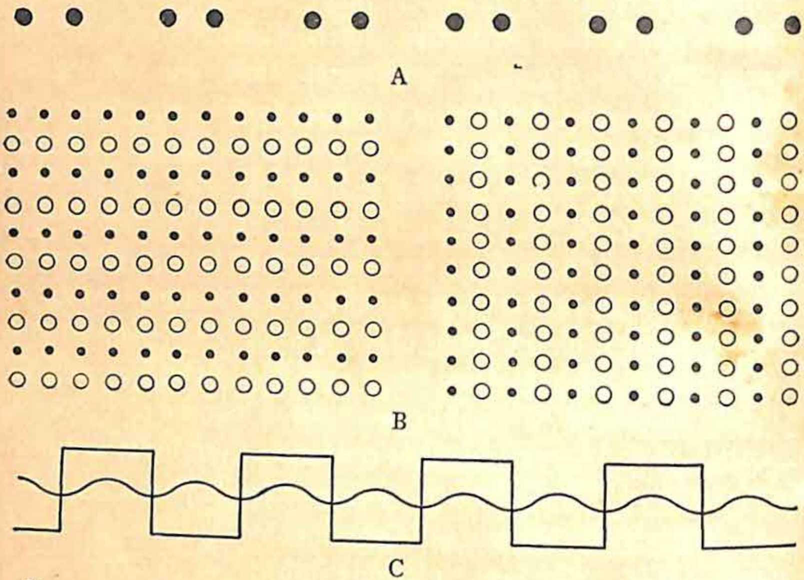


FIG. 94. — (From Wertheimer, 13.) Other dot figures, showing the influence of proximity, of similarity, and of continuity, in determining what groups and figures shall be most readily seen. In A, you may be able, by great effort, to tear apart the pairs consisting of dots that are close together, and see instead pairs composed of adjacent dots that are further apart; but certainly ease of perception favors pairing the dots that are close together. In B you can by effort see rows and columns not composed of similar elements, but grouping similars is the line of least resistance. In C it would take great effort indeed to attach parts of the wavy line to parts of the angular line, so as actually to *see* a design built up of these discontinuous parts.

are certainly familiar enough. What conceals the face is the advantage possessed by the other figures that you do see, an advantage due partly to the primary factors already mentioned, and partly to yet another factor, perhaps as important as any. The whole picture in which the face is hidden is a coherent whole, while the hidden face is but an isolated fragment. You have to lose sight of the coherent whole in order to see the face. So we have our final factor of advantage, which undoubtedly belongs among the primary factors.

7. The *whole that is perceived* gives the advantage to parts coherent with that whole. Parts are perceived as belonging to the whole, rather than separately. This factor is perhaps the same as that of continuity, mentioned above; only that here we stress the whole pattern, object or situation as determining how the parts shall be perceived. In perception, at least, there is much truth in the saying that the whole determines the parts.

Figure and ground. Here we have a very important side of the selectivity of perception. If you draw a square and a much smaller square inside, and simply look at what you have drawn, usually the little square stands out as an object against the background of the enclosing white space. But if you draw the inside square almost as large as the outer one, and parallel to it, then what stands out as the figure is the double square, and the white space inside appears as the background. The figure has form, the ground seems like indefinite space. The figure usually seems to stand out towards you, and the background to extend around behind the figure.

In another square frame, shade in a small portion, not necessarily regular in shape. The dark part then appears as the figure, and the enclosing light part as the ground. For comparison, shade in all of another square except for a small portion, and then the light part appears as the figure against a dark ground.

What shall be seen as figure and what left as ground depends on many conditions. The figure is apt to be compact. It hangs together by virtue of its compactness. But it may be comparatively large, provided it has a definite shape that holds the parts together. In the ordinary field of view, figure and ground are much in evidence. We almost always see some object or shape against a background which appears as relatively uniform and unfigured. It is not true, however, that objects in the background, or to the side, lose all their figure. More than one figure may be seen at the same time, some

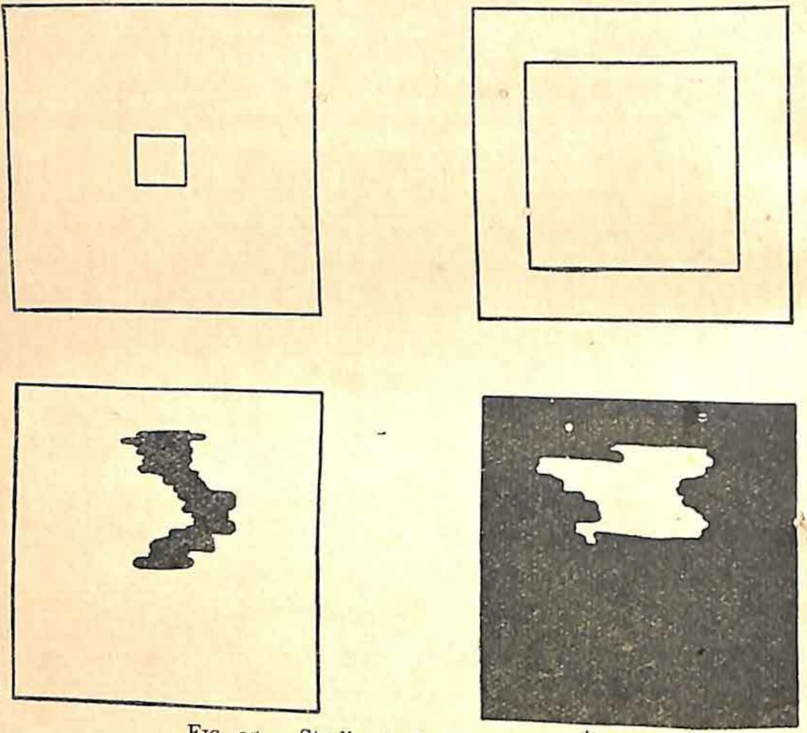


FIG. 95.—Studies in figure and ground.

standing out more clearly than others. So the distinction between figure and ground is not the same as that between the field of attention and the rest of the field of consciousness. You can attend to the ground in any of the drawings used in this experiment, but you are certainly much more apt to attend to the figure.

Figure and ground are nicely illustrated by the tune and accompaniment in music. The tune (air or melody) stands out as figure from the tonal ground of the accompanying chords.

If, however, the accompaniment itself has some tune or rhythm, this secondary figure is heard along with the main tune, and may be combined with it into a compound figure.

Figure and ground show the law of selection operating in the process of perception. The mass of sensations is not seen or heard unselectively, but some figure is discovered in the mass.

THE LAW OF SHIFTING

The shifting of attention. Eye movements afford a good picture of the mobility of attention. Ordinarily the eyes shift at short intervals from one part of the field of view to another. It is almost impossible to hold the eye fixed for any length of time on a simple, motionless, unchanging object.

The shifting of attention is not entirely a motor affair. Looking at a spot of color, you may attend first to its color, then to its shape; listening to a tone, you may attend first to its pitch and then to its loudness, without any need for altering the position of the eyes or head. You can attend to an object off to the side of the point you are looking at, without turning your eyes towards it.

Attention is mobile because it is exploratory; it continually seeks something fresh for examination. In the presence of a complex of sights and sounds and touch stimuli, it tends to shift every second or two from one part of the situation to another. Even if you are lying in bed with your eyes closed, the movement of attention still appears in the rapid succession of thoughts and images.

A different kind of shifting appears in what is called "fluctuation of attention." Make a light gray smudge on a white sheet of paper, and place this at such a distance that the gray will be barely distinguishable from the white background. Looking steadily at the smudge, you will find it to disappear and reappear periodically. Or, place your watch at such a distance that its ticking is barely audible, and you will find the sound to go out and come back at intervals. The fluctuation probably represents periodic fatigue and recovery in the parts of the brain concerned in observing the faint stimulus. It is akin to the oscillations in level of work that are found in a continued task which the worker constantly tries to do as well as possible. Such fluctuations as these are changes in the level of brain activity, while the shifting of attention is an entirely different thing. While the fluctuations may have a period or cycle of twenty seconds or more, the shifts of attention take place at a much shorter interval, from a fifth of a second at the shortest up to a second or two. The shifting represents the movement of attention from one object to the next.

Shifting perception. Under this head may be placed some of the most striking examples of the law of shifting. The object presented remains the same, and attention does not wander from it, but its appearance changes from time to time. A good object for the purpose consists of an assemblage of dots, arranged either regularly or irregularly. One simply looks steadily at the collection, and notices whatever shifting may occur in the grouping of the dots. One is sure to see striking changes. First the dots fall into one pattern, and then, without warning, they shift into a different pattern. The patterns are mutually exclusive; when one comes, the other

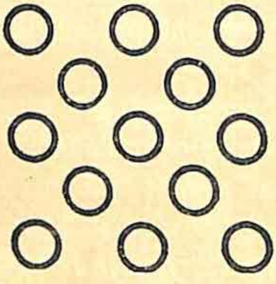


FIG. 96. — (A dot figure, from Sanford, 10.) Look steadily at it.

goes. Now objectively the dots do not change, and therefore the shifting occurs wholly in the observer. As his eyes move from point to point, the stimuli received from the dots shift their positions slightly on his retina, but much more important is the fact that he possesses two or more grouping responses which can easily be aroused by the same collection of stimuli, and that he shifts from one to another of these alternative responses.

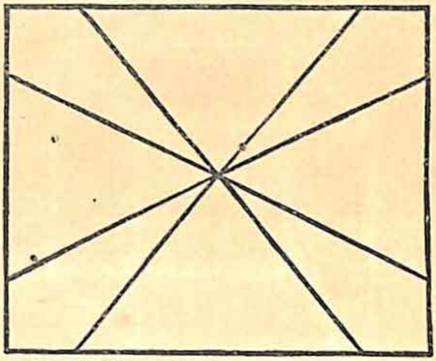


FIG. 97. — (From W. Köhler, 6.) A drawing that can be seen in different ways.

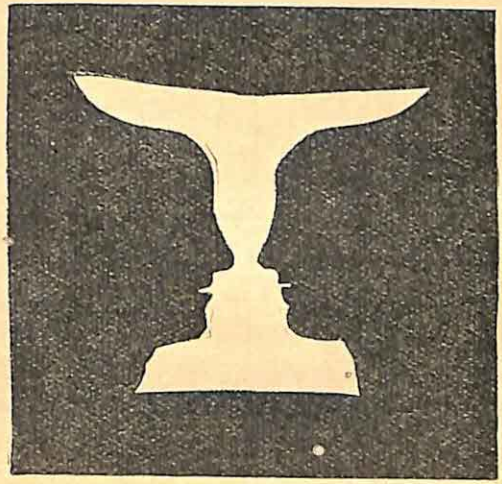


FIG. 98. — (From E. Rubin, 9.) Figure-ground reversal.

Figures that give shifting perceptions can be made of lines as well as of dots. Some shifts amount to an interchange of figure and ground. These figures are so drawn as to admit of two or more interpretations with little advantage to one above the others. The observer can readily see such a drawing in different ways, but not in more than one way at the same time. With continued looking he gets the different appearances in succession, shifting from one response to another as in the case of the dot figure.

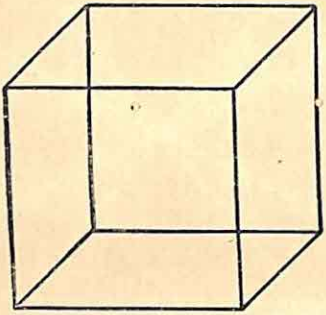


FIG. 99. — The ambiguous cube figure.

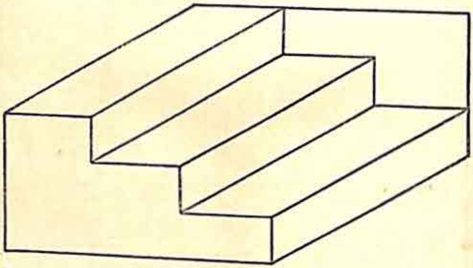


FIG. 100. — The ambiguous staircase figure.

Shifting is especially striking when a drawing is made in ambiguous perspective, so as to represent a solid body equally well in two different positions. The transparent cube, showing near and far edges alike, is a good example. Examined steadily, the cube seems to change from time to time; it is seen, successively, in two different ways. Numerous such figures can be drawn, the most celebrated being the ambiguous staircase. Look steadily at this, and suddenly you see the under side of a flight of stairs, instead of the upper, and if you keep on looking, it keeps on shifting between these two appearances. Certain fixation points for the eye favor one appearance or the other, and yet the appearance does not depend wholly, or mainly, upon the fixation point.

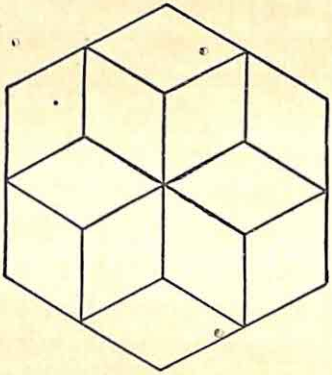


Fig. 101. — Another ambiguous figure. There is really no excuse for seeing anything here but the perfectly good flat figure which probably appears first — no excuse, except our proneness to see solid, three-dimensional objects in all figures that admit of such interpretation.

In this connection, we do well to recall once more the remarkable case of shifting that we noticed before under the name of binocular rivalry, which occurs when lines that will not combine into a single meaningful picture are presented to the two eyes. Binocular rivalry shows both selectivity and shifting (p. 383).

SUSTAINED ATTENTION

Sustained attention does not mean a sort of cramp that keeps attention fixed on one point. It means, rather, that attention, instead of wandering here, there and everywhere, remains on a certain object, or within a certain field, while still moving within that field.

Eye movement, which gave us a picture of the shifting of attention, also indicates the nature of sustained attention. Remember how the eye moves in reading. Every second it shifts, but still it keeps to the line of print. Attention keeps moving forward in the story we are reading, but sticks to the story. The more absorbed we are in the story, the more rapidly we read. Attention is sustained here and still it moves.

What is it, then, that sustains attention? Evidently it is the factor of desire or interest. A continued interest in a game, story or job means that one is keeping pace with what goes on and, to that extent at least, participating in the continuing process. The unanswered question or unsolved problem is one source of continued activity and of sustained interest.

Serious reading as a sustained performance has much to learn from story-reading. Dawdling over a story of adventure must be unusual; one presses eagerly forward to see how the hero can possibly escape from his difficulties. The best readers of serious matter have a similar eagerness to discover what the author has to say; they see the author's question and press on to find his answer. Such readers are both quick and retentive.

Development of attention. For the student, the ideal sustainer of attention is an interest in the subject. If a lesson fails to arouse his spontaneous interest he may have to take it as a " stunt " to be mastered, a spur to his self-assertion. After he penetrates into the subject he may find it inherently interesting, and extraneous motives such as self-assertion or fear of failure may no longer be necessary.

Attention to a subject passes through three stages in its development. First comes the random sort of attention, excited by novelty and change, size and the other unlearned factors of advantage. Next comes the stage of forced attention, driven by extraneous motives. Finally arrives the stage of objective interest (see p. 324).

Distraction. A distraction is anything that works against sustained attention, by competing for attention and having some factors of advantage on its side. A person who has no strong interest in what he is doing, or one who has something else in mind that he would much prefer to do, or one who is not negatively adapted to the noises and other distracting stimuli that reach him, is for the time being a distractible person.

In the insane condition known as the "manic state," or "manic excitement," the patient is excessively distractible (see p. 100). He commences to tell you something, all interest in what he has to say, but, if you pull out your watch while he is talking, he drops his story in the middle and shifts to some remark about the watch. He seems to have no interest persistent enough to hold his attention steady. In the contrary "depressed state," which the same individual may get into at another time, it is almost impossible to distract him, so absorbed is he in brooding over his own troubles. Thus the same individual may be at one time very distractible, at another time quite the opposite; and we do not know as yet what is the cause of this change.

Distraction is a favorite theme for experiment in the laboratory because of the light it throws on sustained attention. The usual result has been that the supposedly distracting stimulus fails to distract. In one experiment college sophomores were given an Army Alpha intelligence test. Two groups of 90 each were carefully equated by a preliminary test, and the experimental group then took the test under conditions of distraction, the control group under conditions of quiet. The distraction consisted of bells, buzzers, whistles, organ pipes, a phonograph and other noises, a spotlight flashing around the walls, and people moving noisily about the room, strangely garbed and carrying strange objects. In short the conditions would have been considered outrageous, had the whole thing not been an experiment. The average scores came out as follows:

Control group, working in quiet	137.6 points
Experimental group, working under distraction	133.9 "
Apparent loss through distraction	3.7 "

The apparent loss is only 3 percent; some individuals doubtless lost considerably but others must have actually gained from the distraction (4).

Such stimuli as were used in this last experiment were strong rather than appealing. When beautiful music and humorous anecdotes were used by another investigator (12) while the subjects were engaged in adding, memorizing, or solving riddles, every one of the 16 subjects showed some loss of output, ranging from 8 to over 50 percent. They sometimes lost track of the task and gave themselves up for a time to the story or music. At other times they fought off the distraction by a great expenditure of muscular energy. Better than fighting off the distraction was an increased positive concentration upon the task.

Overcoming distractions. There are several ways of overcoming a distraction. First, greater energy may be thrown into the task one is trying to perform. The extra effort usually shows itself in gritting the teeth, reading aloud, and similar muscular activity, all useless for executing the task in hand, but somehow helping to keep one's energy within the task (p. 323). Second, one may form a habit of inattention to an often recurring distraction, and come to disregard it without effort. Third, there is a very different way of dealing with a distraction, which works very well in certain cases, and that is to couple the distraction to the main task. An example is seen in piano playing. The beginner at the piano likes to play with the right hand alone, because striking the bass note with the left hand distracts him from striking the "air" with his right hand. But, after practice, he couples the two hands, and strikes the whole chord at once, much to his satisfaction. Coordination here is essentially the same thing that we noticed before in connection with conflicting motives.

Doing two things at once. The law of selection brings to mind the question that is often asked, "Can anyone do two things at once?" In this form, the question admits of but one answer, for we have no trouble in breathing and walking at the same time, nor in thinking while breathing and walking. But breathing and walking are so automatic as to require no attention. The more important question is whether we can do two things at once, when each demands careful attention.

Julius Cæsar, it is said, used to dictate at once to several copyists. Now, as Cæsar's copyists were not stenographers, what he had to do was to give the first copyist a start on one letter, then give the second a start on another letter, and so on, getting back to the first in time to keep him busy. Quite an intellectual feat, certainly! But not a feat requiring absolutely simultaneous attention to several different matters. In a small way, anyone can do something of the same kind. You can add a column of numbers while reciting a familiar poem; you get the poem started, let it run on automatically for a few words while you add a few numbers, switch back to the poem and then back to the adding. But in all this there is no doing of two things, attentively, at the same instant of time.

Definite experiments on doing two things at once, such as adding columns of numbers while listening to a story which one has to reproduce afterwards (11), show that the subject shifts back and forth between the two tasks. He loses the story from time to time, but pieces it together as well as possible. If the adding is very easy for him, he may do it almost automatically, and have most of his attention for the story. But he never adds as efficiently as he would if not listening to the story, and he never hears the story as well as he would if not adding. On the average, and with great individual differences, he does about 60 percent as well in these simple tasks combined as he would in performing them separately. Even a task so simple as writing "+ − + − + −," and so on, disturbs the following of the story.

It appears, however, that a mere posture demanding *moderate muscular tension* but almost no attention — as in steadily squeezing two hand dynamometers — has a facilitating, not an inhibitory effect on a simultaneous adding or memorizing performance (3). This last result suggests that the involuntary muscular tensions of jaw, brow, neck, hands, body and legs, which so regularly accompany intense mental effort, may have a genuine stimulating effect upon mental activity. However, the matter is not altogether simple, for it has also been found that adding and memory tasks are better performed in a lying than in a standing position; and inquiry among eminent writers showed that a large number, probably well over half of them, were accustomed to recline, put their feet on the table, or otherwise adopt an approximately horizontal position, when doing their most active mental work (5). The horizontal position favors brain circulation. There is also some evidence, not experimental however, that the most efficient brain workers get along with a minimum of muscular tension. Evidently the conditions of effective mental work are complex, but concentration of attention, and freedom from distraction and from incidental performances, are no doubt favorable on the whole.

LIMITATIONS AND ERRORS OF OBSERVATION

A very practical question, and one also of much scientific interest, concerns the limits of our powers of observation. How much and how accurately can we observe? Evidently there are limits, and their causes may be either "central" — in the brain — or peripheral — elsewhere in the organism, especially in the sense organs. As examples of peripheral limitations we may cite the meager data furnished by the ears towards locating the source of a sound; the limited extent of the visible spectrum; and the relatively small area of distinct vision. Under the head of central limitations we can include bias, preoccupation and suggestion, any one of which may falsify observation. We can include also the time and labor necessary for observation of details. It is easier and more comfortable to observe large patterns and totals. Unanalyzed total impressions, however, often prove inadequate for practical purposes, and we are driven to study out details. The child at first treats gloves as all alike, whether rights or lefts, but not being able to manage them on that basis he begins to look at them more sharply.

The span of apprehension. Somewhat akin to the memory span that we heard of before, the span of apprehension is the answer to the question, how many objects we can perceive at once. Measurement of this span is one of the oldest experiments in psychology, made at first with very rough apparatus. Someone places a few marbles in a box, you take a single peek and tell, if you can, how many are there, not guessing but knowing. The span measures about four or five, if no errors are allowed.

In the laboratory we have exposure apparatus that displays a card for a fifth of a second or less, just time enough for a single view and not enough to look the card over. The experimenter prepares many cards, each containing a number of dots, scattered irregularly over the card, and exposes the cards one at a time; and the subject attempts to see all the dots, and tell how many there are. If there are only two, three or four on a card, the subject probably reports the number correctly every time; with five, an occasional error can be expected, and the errors increase gradually till at about twelve dots the subject can only guess. Thus the span is a variable quantity even with the same individual, and it varies from individual to individual.

But how, it may well be asked, can the subject in this experiment observe as many as eight or ten dots, with no time during the exposure for counting? The visual after-image helps somewhat, and the primary memory-image still more. But the most important aid is *grouping*. If there are only three or four dots, they form a single group; if there are seven, they probably appear as a group of four and a group of three. Unless the dots do fall instantly into groups, the subject cannot usually tell the number. If the experimenter has grouped them objectively, or arranged them in a regular system, the subject's task is simplified.

If the material exposed, instead of being mere dots, consists of a line of letters, three or four can be clearly read at a glance. If the letters make up familiar words, two or three words can be read at a glance. And if the words make up a familiar phrase, the whole phrase, containing as many as twenty letters, can often be read at a single glance.

The limited span of perception is another instance of selectivity. The eye furnishes more data than the brain can use. It is not because the area of clear vision is limited that the span of apprehension is so small; for the experimenter can easily arrange to present twenty dots within the area of clear vision, but the subject cannot organize so many in a moment. Perception evidently means work, and thus is forced to be selective.

If the limited span shows the law of selection, grouping shows the law of combination. Little items like dots or letters do not arouse each its own separate response, but several of them, together, arouse a single response (7).

Constant and variable errors of observation. If you come out of a cold room into a warm room, the latter seems warmer than it is; and if you come out of a dark room into a light room, the latter seems brighter than it is. These errors are due to peripheral factors, to adaptation of the temperature sense and of the retina.

One minute, when you are impatiently waiting for it to be finished, seems an incredibly long time. But when you are working against time, a minute seems short. The professor is shocked when the closing bell rings, and thinks that certainly the hour cannot be up; but some of the students have been consulting their watches for quite a long while. These errors are due to central factors.

Where we tend to err in one certain direction from the truth, as in the examples just cited, psychology speaks of a *constant error,* and evidently the knowledge of such constant errors is of importance wherever the facts are of importance. In a court of law, a witness often has to testify regarding the length of time occupied by some event, and a knowledge of the constant errors in time perception would therefore be of legal importance. They would need to be worked out in detail, since they differ according to the desires and attitude of the witness at the time of the event.

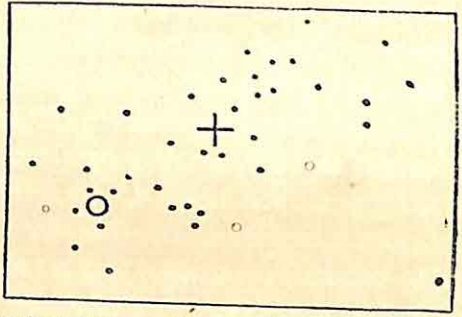


FIG. 102. — Constant error and scatter in hitting at a target. The little circle was the target, but the center of the actual distribution of the attempts lies at the cross, which was drawn in afterwards. The constant error could be stated by saying that the center of distribution was so far from the target, and in such and such a direction. The scattering of the attempts can be measured also.

Besides constant errors, there are variable errors, due to momentary causes. Both constant and variable errors can be illustrated by a series of shots at a target. The *variable error* is illustrated by the scatter of the hits, and the constant error by the excess of hits above the bull's-eye, or below, or to the right or left. The constant error can be corrected, once you know what it is; if results show that you tend to shoot too high, you can deliberately aim lower. But the variability of any performance cannot be eliminated except by long practice, and not altogether even then.

Accuracy of perception. How small a difference in length can be perceived by the eye, how small a difference of weight by the hand — these are sample problems under this head.

For example, to measure the fineness with which weights can be perceived when "hefted" in the hand, you take two objects alike in size and appearance but differing slightly in weight, and endeavor to decide which is the heavier by lifting them. You try repeatedly and keep track of the number of errors. If one weight were twice as heavy as the other (one, for example, weighing 100 grams and the other 200), you would never make an error except through carelessness; but if one is 100 and the other 120 grams, you make an occasional error, and the number of errors increases as the difference is decreased; finally, comparing 100 and 101 grams, you get almost as many wrong as right, so that your perception of that small difference is extremely unreliable.

ERRORS IN PERCEIVING SMALL DIFFERENCES OF WEIGHT

(After W. Brown, 2)

Difference	20	16	12	8	4	3	2	1	grams
Errors	1	2	5	13	28	31	39	44	per hundred trials

The weights were in the neighborhood of 100 grams; each weight was compared with the 100-gram weight, and each such pair was lifted and judged 1400 times. Notice that the percent of errors gradually increases as the difference becomes smaller.

The smaller the difference between two stimuli, the more errors are committed in perceiving it and the less perceptible it is; and there is no fixed line between a difference that can be perceived and one that is too small to be perceived. That is the first result from the study of the perception of small differences.

The second result is called *Weber's law,* which can be stated as follows: In the same sort of perception, equal relative (not absolute) differences are equally perceptible. For example, from the preceding table we see that 28 errors per hundred trials are made in comparing weights of 100 and 104 grams; then, according to Weber's law, 28 per hundred would also be made in comparing 200 grams with 208, or 500 with 520, or 1000 with 1040 grams, or any pair of weights that stood to each other in the ratio of 100 to 104. Weber's law is only approximately true for the perception of weights, since actually fewer errors are committed in comparing 500 and 520 than in comparing 100 and 104 grams; but the discrepancy is not extremely great here, and in some other kinds of perception, as especially in comparing the brightness of lights or the length of seen lines, the law holds good over a wide range of stimuli and only breaks down near the upper and lower extremes. We are familiar, in ordinary life, with the general truth of Weber's law, since we know that an inch would make a much more perceptible addition to the length of a man's nose than to his height, and we know that turning on a second light when only one is already lit gives a much more noticeable increase of brightness than if we add one more light when twenty are already burning. The larger the *relative* change, the more perceptible.

A third result of this line of study is that different sorts of perception are very unequal in their fineness and reliability. Perception of brightness is about the keenest, as under favorable conditions a difference of one part in one hundred can here be perceived with very few errors. Visual perception of length of line is good for about one part in fifty, perception of lifted weight for about one part in ten, perception of loudness of sound for about one part in three.

ILLUSIONS

When any process goes wrong it is apt to reveal itself more clearly than when it is running smoothly. We may hope, then, to learn something of the process of perception from the study of illusions.

An illusion is a false perception. Any error of observation, such as have already been noted, might accordingly be included under the head of illusions, but the term is usually reserved for errors that are large and surprising. An illusion consists in responding to a sensory stimulus by perceiving something that is not really there. Something is there and has delivered a stimulus, but the stimulus is misread. Instead of the true object a false object is perceived. The false object must have some advantage over the true object, and illusions can be classified according to the factor of advantage that enters and causes the false perception. Aside from a few illusions which seem to be due to peculiarities of the peripheral organs — such as the fact that a vertical line looks longer than an equal horizontal line — the following classes are recognized.

1. **The false object has the advantage of familiarity.** A stimulus (or combination of stimuli) which is nearly identical with that commonly received from a certain object easily arouses the old familiar response of perceiving that object. One illusion of this type dates from Aristotle (B.C. 330), the first man to write books on pyschology. Cross two fingers, and touch a marble with the crossed part of both fingers, and you seem to feel two marbles. A pencil can be used in place of the marble. In the usual position of the fingers, the stimuli thus received would be rceived from two objects, not from one.

Another good instance of this type of illusion is called the "proofreader's illusion," though the professional proofreader is less subjcet to it than anyone else. It is almost impossible to find every misspelled word and other typographical error in reading proof. Almost every book comes out with a few such errors, in spite of having been scanned repeatedly by several people. A couple of misprints have purposely been left in the last few lines for the reader's benefit. If the word as printed has

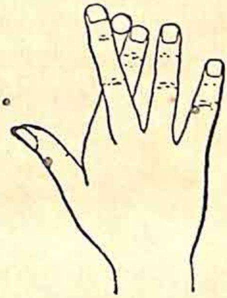


FIG. 103.—Aristotle's illusion.

enough resemblance to the right word, it arouses the same response and enables the reader to get the sense and pass on satisfied.

2. **The false object has the advantage of preparatory set.** When an insane person hears the creaking of a rocking-chair as the voice of someone calling him bad names, it is because he is preoccupied with suspicion. We might almost call this an hallucination since he is confusing his auditory images with sensations; it is, at any rate, an extreme instance of illusion. In a milder form, similar illusions are often momentarily present in a perfectly normal person, who while searching for a lost object may think he sees it whenever anything similar meets his eyes; or, it may be, the mother, with the baby upstairs very much on her mind, imagines him crying when she hears a cat yowling out of doors. The ghost-seeing and burglar-hearing illusions belong here as well. The expectant set gives the advantage to objects congruous with itself.

The "size-weight" illusion shows the effect of preparatory set in a very different way. This interesting laboratory experiment follows up the old catch, "Which is heavier, a pound of lead or a pound of feathers?" A pound's a pound, we shrewdly answer. But lift them, and the pound of lead feels very much heavier. To standardize the conditions, you take two round wooden pill-boxes, one much larger than the other, and load them with paraffin and shot so that both weigh the same; then ask someone to lift them. He will have no doubt at all that the smaller box is the heavier; it may seem twice as heavy. The visual appearance of the two boxes has aroused an adjustment to their apparent weights, with the result that the larger box is lifted strongly and comes up easily, while the little box is lifted weakly, comes up slowly and feels heavy. In this case perception swings to the opposite of what is expected, because the stimulus received simply will not fit in with the expectation, while in the other cases cited the stimulus can be made to fit and is perceived in accord with the expectation.

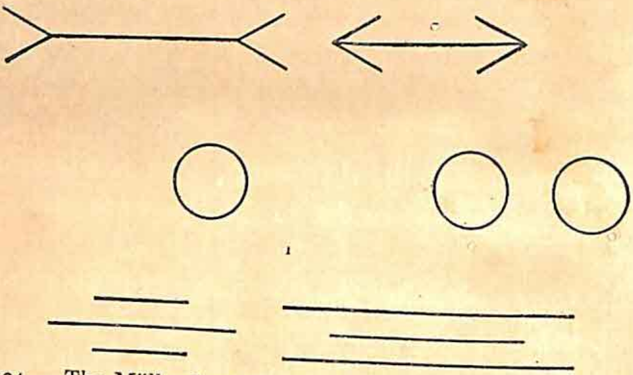


FIG. 104. — The Müller-Lyer illusion, in three forms. In the first figure the two parts of the horizontal line are to be compared in length. The oblique lines create bulky sections of the figure which can be perceived more easily than the precise parts one means to compare. In the second form one has to compare the distance between the adjacent rims of circles 1 and 2 with the distance between the opposite rims of circles 2 and 3. It would be much easier and less analytic to compare the distances between the circles taken as wholes. In the third form the lengths of the middle lines are to be compared. All the six lengths in question are drawn to be objectively equal.

3. The false object has the advantage of total impression. The true object or fact can often be perceived only by analysis of the total impression and attention to detail — a laborious

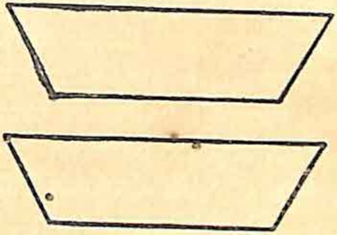


FIG. 105. — The pan illusion. Which pan appears the larger? The whole figure suggests one pan fitting into the other and makes it difficult to isolate the parts one needs to compare.

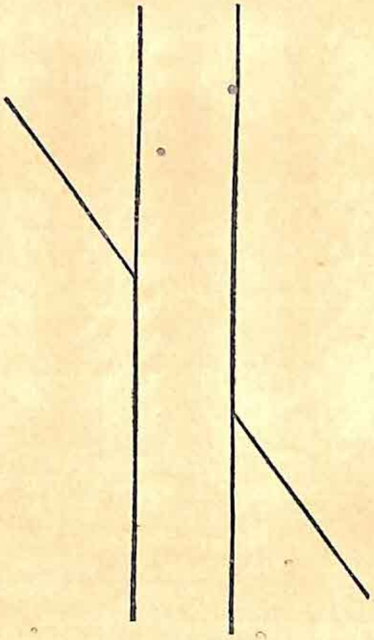


FIG. 106. — The Poggendorf illusion. The question is whether the two obliques are parts of the same straight line.

process as we have seen. Under this head belong a whole army of illusions produced by odd combinations of lines. A figure is so drawn as to hamper the observer in isolating the fact which he is supposed to perceive. The best example is the Müller-Lyer figure, in which there are two equal lines or distances to be perceived, embellished however with extra lines which lead the observer astray. While intending to compare the two specified lines he is more likely to take the whole figure in the rough and to compare the distances between its main masses. He does not succeed, unless after practice, in isolating the precise object he intends to observe.

The pan illusion clearly results from this difficulty of isolating a precise fact from a global impression. Two other famous illusions which are shown here are not quite so readily understood but probably belong under this general head.

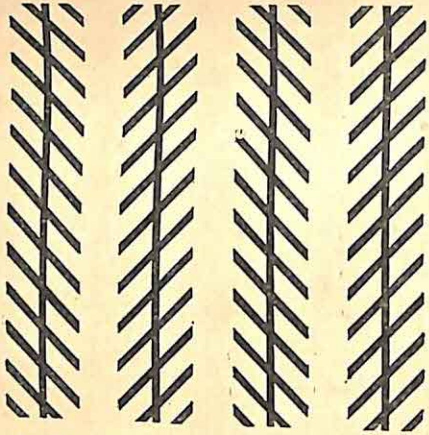


FIG. 107. — The Zoellner illusion. The long lines are really parallel. The illusion is increased by holding the figure so that these main lines are neither vertical nor horizontal. It is more difficult to deceive the eye in regard to the direction of vertical and horizontal lines than in regard to the direction of oblique lines. This illusion must be related in some way to the Müller-Lyer and Poggendorf illusions, since the elements employed in constructing the three figures are so much the same.

If you hold this figure nearly on a level with the eyes and sight along the obliques, you get an illusion of perspective.

Though these illusions seem mere curiosities, and far from everyday experience, they enter in some degree into every figure that is not perfectly square and simple. Any oblique line or complication of any sort is sure to alter the apparent proportions and directions of the figure. A broad effect, a long effect, a skewed effect, may easily be produced by lines introduced into a dress, into the front of a building, or into a design of any sort; so that the designer needs to have a practical knowledge of this type of illusion. The esthetic effect of a given form may be quite altered by the introduction of apparently insignificant extra lines.

To judge from these various illusions, poor observation results (a) from sticking in old ruts and being closed to new impressions, or (b) from preoccupation and bias, or (c) from resting content with total impressions. The good observer is able to escape from these lines of least resistance, and to use some freedom in his outlook on the environment. And yet he has to use the same "factors of advantage" in his good observation. Without a background in past experience he would be lost in a new situation, not knowing what to look for. Without preparatory set he would be looking for nothing in particular and probably would find nothing. Without grasping patterns and relationships he could see only isolated and insignificant details. The good observer needs to have the virtues of his defects and to escape from the defects of his virtues.

VARIETIES OF OBSERVATION

In the present chapter we have confined ourselves mostly to laboratory experiments which served to bring out such fundamental characteristics of perception as its shifting and its dependence on certain factors of advantage. We have noted its tendency towards groups and total impressions, and also its tendency to isolate figure from ground. We need now to remind ourselves that what we usually see is not so much a figure or group as an object in the environment. We see not the mere field of view but a field of objects, an objective situation.

We see the location, size, shape and color of objects, their motions and changes. Similarly we hear, feel, taste and smell objects. To say that we observe not isolated stimuli but their groupings and patterns is true but goes only halfway. What we observe consists of things and events, with their qualities and relations.

Signs and meanings. We need to stress more than has been done in this chapter the fact that perception is very much affected by learning. There is a two-way relation between learning and observation; for while we learn largely by observation, we observe largely by use of what has previously been learned.

The facts that we perceive are often not fully presented to the senses at the moment; they may be merely indicated. We may have before our eyes merely a *sign* of some fact, but we perceive the fact which is the *meaning* of the sign. We look out of the window and "see it is wet today," though wetness is something to be felt rather than seen. What we have before our eyes is some cue or sign of wetness. Sign and meaning are connected by learning, and meaning may be called a conditioned response to the sign. For Pavlov's dogs the bell followed regularly by food became a sign of food. In the same way, the child sees a bit of ground that looks peculiar, steps there and is gratified to find a puddle; so the visual appearance becomes a sign of wetness.

A sign is essentially the same thing as was called a *reduced cue* for recall and recognition (pp. 290, 293). Examples of reduced cues in perception could be multiplied without limit. The outline drawings of persons, animals, houses, trees, that are common in children's picture books, and that the child understands at an early age, are certainly much reduced from the visual appearance of the real objects. A person or thing seen in the distance presents a much smaller and less detailed picture than when close at hand, but still can be recognized.

Social perception. By the senses we perceive the motives and intentions of other people, their sincerity, intelligence and many other traits. We see them angry, bored, amused, full of energy. To be sure, none of these human characteristics is directly and fully sensed, but that is the case also with many characteristics of inanimate objects which, nevertheless, we perceive by aid of the senses. We perceive anger or sincerity in much the same way that we perceive moisture by the eye. To experience the anger of another person is a complex experience, but a single element from this experience may come to serve as the sign of the whole condition. A good share of the child's undirected education consists in learning to perceive the intentions and characteristics of other people by aid of little signs. He learns to read the signs of the weather in the family circle, and he learns in some measure to be a judge of men.

It would be very valuable if psychology could succeed in analyzing out the signs by which such a trait as intelligence or "will power" is perceived, so as to reduce such perception to a science. Some persons who themselves are keen observers of such traits have put forward systems, based upon the shape of the face, etc. They think they perceive human traits according to their systems, but the systems fail in other hands, and are undoubtedly fallacious. No good judge of character really relies on the shape of the face; he relies on little behavior signs which he has not analyzed, and therefore cannot explain to another person.

You can tell very little regarding a person's intelligence from his photograph. Photographs of persons of various degrees of intelligence are placed before those who are reputed to be good judges, and their estimates compared with the test ratings, and there is no close correspondence. You might almost as well look at the back of the photograph as at the front.

Even with the person before you, you are likely to commit great errors. This sort of incident has happened. A young woman is brought before the court for delinquency, and the psychologist who has tested her testifies that she is of low intelligence. But the young woman is good-looking and graceful in her speech and manners, and so impresses the judge that he dismisses as absurd the notion of her being feebleminded. He sets her free, on which she promptly gets into trouble again. Apparently the only way to perceive intelligence is to see a person in action, or to see the results of his activity.

Esthetic perception. Beauty and humor can be observed through the senses, though we might debate for a long time over the question whether they are facts in the environment. Is a landscape beautiful when no one is there to see it, and is a situation funny if no one is actually amused? At any rate, such esthetic values are observed, though there are great individual differences between observers. Some people are blind to beauty and humor that other people clearly perceive. Many a one fails to see the point of a joke, or the humor of a situation, which is clearly perceived by another. Many a one sees only a sign of rain in a great bank of clouds, only a weary climb in the looming mountain.

> "A primrose by the river's brim
> A yellow primrose was to him,
> And it was nothing more."

It would not be quite fair to describe such a one as lacking in feeling; he probably has on occasion the same feelings as another man, but he is lacking in perception of certain values. He probably tends to practical rather than esthetic perception. To see any beauty in a new style of painting, or to sense the humor in a new form of humorous writing, you need to be initiated. A complex situation presents almost an unlimited range of facts that might be perceived; no one perceives them all, and which ones he shall perceive depends on his nature and training, as well as on his attitude at the moment when the situation is presented.

Beauty and ugliness can be seen in the very simplest objects. You would scarcely suppose that a mere rectangle could produce any esthetic effect; yet it is found that some rectangles are preferred to others, and that the popular choice falls upon a proportion long known to art-theorists as the "golden section," the width being about sixty-two percent of the length. Again, however much you may like symmetry, you can scarcely suppose it makes much difference exactly where a horizontal line is cut by a short cross line; yet nearly everyone on being put to the test selects the middle as the best point. Though the causes of these preferences are not surely known, we may hazard the conjecture that they are radically different in the two cases. Symmetry probably appeals to us, directly or indirectly, because we ourselves are symmetrical. We are symmetrical from side to side and we like a cathedral to be so, not insisting that it be symmetrical from front to back. On the other hand we are much slimmer than the golden section, and our preference here must have a less personal, more objective basis. Probably the golden section rectangle appears typical for a rectangle, slim enough to be a successful rectangle without being extreme. There is a suggestion here of two ways of perceiving objects: either in relation to ourselves, or in relation to other objects. The latter mode of perception is more thoroughly objective and, as we shall see in the next chapter, is of great importance in building up an adequate understanding of the world about us.

REFERENCES

1. Adams, H. F. *Advertising and its mental laws.* 1920.

2. Brown, W. "The judgment of difference." *Cal. Univ. Pub.,* 1910, 1, 1–71.

3. Bills, A. G. "The influence of muscular tension on the efficiency of mental work." *Amer. J. Psychol.*, 1927, 38, 227–251.

4. Hovey, H. B. "Effects of general distraction on the higher thought processes." *Amer. J. Psychol.*, 1928, 40, 585–591.

5. Jones, E. E. "Influence of bodily posture on mental activities." *Arch. Psychol.*, 1907.

6. Köhler, W. *Gestalt psychology.* 1929.

7. Oberly, H. S. "The range for visual attention, cognition and apprehension." *Amer. J. Psychol.*, 1924, 35, 332–352.

8. Poffenberger, A. T. *Psychology in advertising.* rev. ed., 1932.

9. Rubin, E. *Visuell wahrgenommene Figuren.* 1921.

10. Sanford, E. C. *Experimental psychology.* 1898.

11. Sterzinger, O. "Verteilung der Aufmerksamkeit." *Zt. angew. Psychol.*, 1928, 29, 177–196.

12. Weber, H. "Untersuchungen über die Ablenkung der Aufmerksamkeit." *Arch. ges. Psychol.*, 1929, 71, 185–260.

13. Wertheimer, M. "Untersuchungen zur Lehre von der Gestalt." *Psychol. Forsch.*, 1923, 4, 301–350.

CHAPTER XVII

THINKING

The ability to think, plan, systematize and reason is so characteristically human and of so high an order that we are tempted to assume a rational activity in man that is altogether new, and different from anything we have found in learning, memory, sense perception or motor activity. But, so far as the thinking processes have been studied — they are not easily subjected to exact observation and experimentation — nothing radically new and different has been revealed. Apparently there is no new type of activity involved in thinking, but rather a combination of elementary forms of activity which we have already met, especially of:

1. orientation towards a goal;
2. seeking this way and that for an approach to the goal;
3. recall of previously observed facts;
4. grouping and patterning of these facts;
5. inner speech and gestures.

Not all of these activities are present in every instance of thinking. There is such a thing as idle thought, with no particular goal; and there may be thought without inner (or outer) speech. In some thinking there is no grouping and patterning of recalled material. If we choose to include all sorts of "insight" by animals and young children (see p. 242), some thinking does not even make use of recalled facts. Quite a variety of intellectual processes can be included under this broad head of thinking, and some of them scarcely differ from observation, though all do differ from mere motor activity. Typically, thinking brings together by recall facts observed at different times and places, groups them into new patterns and in these patterns discovers something new to the individual.

Before taking up mental work and reasoning, in which there is a controlling task or goal, we may take note of the simpler types of thinking that go under the name of free association.

FREE ASSOCIATION

Mental processes that make use of previously observed facts, and so depend on the recall of those facts, are often called "associative activities," since they make use of associations or linkages formed in previous learning. When some definite interest or purpose steers the associative processes, we speak of "controlled association," contrasting this with the "free association" that occurs in an idle mood, when one thought simply calls up another with no object in view.

Revery affords the best example of free association. I see my neighbor's dog out of my window, and am reminded of one time when I took charge of that dog while my neighbor was away, and then of my neighbor's coming back and taking the dog from the cellar where I had shut him up; next of my neighbor's advice with respect to an automobile collision in which I was concerned; next of the stranger with whom I had collided, and of the stranger's address on the card which he gave me; next comes a query as to this stranger's line of business and whether he was well-to-do; and from there my thoughts switch naturally to the high cost of living.

This is rather a drab, unexciting type of revery, and youth might show more life and color; but the linkages between one thought and the next are typical of any revery. I had previously observed the ownership of this dog by my neighbor, and this observation linked the dog and the neighbor and enabled the dog to recall the neighbor to my mind. One fact recalls another when the two have been previously observed as belonging together.

But suppose, as is commonly the case, that a fact has been linked, in different past experiences, with several different facts. Then two questions arise: whether all these facts are recalled; and, if not, what gives the advantage to the fact actually recalled.

The answer to the first question is plain. The fact first present in mind does not call up all the associated facts, but usually only one of them, or at least only one at a time. My neighbor, in the example given, though previously associated with a dozen other facts, now calls up but two of these facts, and those two not simultaneously but one after the other. This is the way our familiar *law of selection* (see p. 421) works out in the associative processes.

The *factors of advantage in free association* have already been mentioned under the head of learning (see p. 256); they are:

> the *frequency* with which the linkage has occurred;
> the *recency* with which it has occurred; and
> the *intensity* with which it has occurred.

If I have frequently observed the connection of two facts, the linkage between them is strong; if I have recently observed their connection, the linkage between them is strong till the "recency value" dies away; and if my observation of the connection of the two facts was a vivid experience, or intense reaction, then, also, the linkage between them is strong. If these three factors of advantage work together in favor of the same response, then that response is sure to occur; but if the three factors pull different ways, we should have to figure out the balance of advantage before we could predict which of the possible responses would actually be made. Strong recency value offsets a lot of frequency; so that a mere vague allusion to a very recent topic of conversation can be depended on to recall the right facts to the hearer's mind. "James," by virtue of frequency, means your brother or friend; but when the lecturer is talking about the psychologist James, repetition of this name infallibly recalls the psychologist to mind.

Besides frequency, recency and intensity, there is, indeed, another factor to be taken into account; and that is the present state of the individual. If he is unhappy, unpleasant associations have the advantage; if happy, pleasant. If he is absorbed in a given matter, facts related to that matter have the advantage. Frequency, recency and intensity summarize the *history* of associations, and measure their strength as dependent on their history; but the present state of mind is an additional directive factor, and when it has much to do with recall, we speak of directed or controlled association.

The free association test. Before we pass to the topic of controlled association, however, there is another form of free association to be examined. There is an experiment in which the subject is given a series of words as stimuli, and is asked to respond to each word by speaking some other word. No special word need be spoken, but simply the *first word recalled*. Though this is called free association, it is controlled to the extent that the response must be a word, and the result is very different from revery. Instead of the recall of concrete facts from past experience, there is recall of words. If you give the subject the stimulus word, "table," his response is "chair" or "dinner," etc., and often he does not think of any particular table, but simply of the word. Words are so often linked one with another, it is no wonder that one recalls another automatically. What particular word shall be recalled depends on the frequency, recency and intensity of past linkage.

Though this form of test seems so simple as almost to be silly, it is of use in several ways. When the responses are classified, some individuals are found to favor linkages that have a personal significance — "egocentric responses," these are called — while other individuals run to impersonal and objective connections. Thus the test throws some light on the individual's habits of thought.

The test has also a "detective" use, based upon the great efficacy of the factor of *recency*. If an individual has recently committed some crime, properly selected stimulus words will lead him to recall the scene of the crime, and thus to make responses that betray him, unless he checks them and so arouses suspicion by his hesitation. This device has been used successfully in some cases, but has not been adopted as regular police procedure.

Another use of the test is for unearthing a person's emotional "complexes," which of course possess a high *intensity* value. Hesitation and embarrassment in responding to words referring to money indicate that the subject is emotionally disturbed over the state of his finances. One person who consulted a doctor for nervousness made peculiar responses to stimulus words relating to the family, and was discovered to be much disturbed over his family's opposition to his projected marriage. The free association test is useful rather as giving the experienced psychologist hints to be followed up than as furnishing sure proof of the contents of the subject's mind.

CONTROLLED ASSOCIATION

There is a controlled association test conducted like this one in free association, except that the subject is required to respond to each stimulus word by a word standing in a specified relation to it. To one series of words he must respond by saying their opposites; to another, by mentioning a part of each object named; and there are many tests of this sort, each dealing with some class of relationships. The intelligent subject makes few errors in such a test, and responds in very quick time. Indeed, the remarkable fact is that he takes less time to respond cult problem, however, differs from a familiar task in this important respect, that the appropriate response has not been previously linked with the present situation, so that, in spite of ever so good a set, the right response cannot immediately be aroused. One must *search* for the response, but the set is useful in directing the search. Problem solution is so different a process from smooth-running controlled association that it deserves separate treatment, which will be given under the caption of reasoning.

REASONING

Reasoning may be described as mental exploration. Suppose you need the hammer, and go to the place where it is kept, only to find it gone. Now if you simply proceed to look here and there, ransacking the house without any plan, that would be motor exploration. But if, finding this trial and error procedure to be hopeless, you sit down and think, "Where can that hammer be? Probably where I used it last!" you may recall using it in a certain place, go and find it there. You have substituted mental for motor exploration, and saved time and effort.

The *process* of reasoning is illustrated very well in this simple case. In a way, it is a trial and error process. If you don't ransack the house, at least you ransack your memory. You recall this fact and that, you turn this way and that, mentally, till some fact is recalled that serves your need. No more in reasoning than in motor exploration can you hope to go straight to the desired goal.

The reader familiar with geometry, which is distinctly a reasoning science, can readily verify this description. It is true that each demonstration is set down in the book in an orderly manner, proceeding straight from the given assumption to the final conclusion; but such a demonstration is only a dried specimen and does not by any means picture the living mental process of reasoning out a proposition. Solving an "original" is far from a straightforward process.

Reasoning, following one clue after another, certainly has the form of trial and error. It differs from mere trial and error in that it follows clues by thinking them through, instead of by motor exploration. It follows them by recall of previously observed facts. Often, to be sure, reasoning cannot reach a solution, cannot think its clues through to the bitter end, but must yield to actual exploration and the observation of fresh facts.

Reasoning culminates in inference. When you have described reasoning as a process of mental exploration, you have told only half the story. The successful reasoner not only seeks, but finds. He not only ransacks his memory for data bearing on his problem, but, when memory has supplied the data, he sees their bearing on the problem. What the exploratory process does for him is to assemble data from different sources, and his job then is to see what the data mean when taken together. He must grasp the interrelations of the data, he must get the pattern of the grouped data. He finally sees that something *must be so*. This type of seeing or grasping is called *inference.*

To bring out distinctly the seeing or grasping that occurs in reasoning, let us examine a few simple cases. Two freshmen in college, getting acquainted, find that both their fathers are alumni of the same college. "What class was your father in?" "In the class of 1900. And yours?" "Why, he was in 1900, too. Our fathers were in the same class; they must know each other!" Here two facts, one contributed by one person and the other by another person, enable them to see or infer a third fact which neither of them knew before. Inference, typically, is a response to two facts, and the response consists in seeing a third fact bound up in the other two.

You do not need to infer what you can perceive directly by the senses. If Mary and Jane are standing side by side, you see which is taller. But if they are living far apart, you can still infer which is the taller, provided each one is measured with a good yardstick and the two facts compared.

Of the two facts which, taken together, yield an inferred fact, one is often a general rule or principle, and the inference then consists in seing *how the general rule applies* to a special case. A dealer offers you a fine-looking diamond ring for five dollars, but you recall the rule that "all genuine diamonds are expensive," and perceive that this diamond must be an imitation.

Difficulties in reasoning: the exploratory stage. Compared with sense perception or with such associative processes as reading or adding, reasoning is an unstandardized and inefficient process and encounters many difficulties. Difficulty is encountered both in the preliminary stage of exploration and in the critical stage of inference. The difficulties of the exploratory process are illustrated in the solution of the problems used in the study of learning (see pp. 226–245). Even maze learning, though scarcely to be achieved by purely mental exploration, affords a clue to the sources of difficulty in reasoning. The rat, we found, learns the locality, and, when reward is introduced, quickly becomes oriented towards the goal. In mental exploration, too, the fundamental necessities are to become acquainted with the field or situation, and to obtain an orientation or steer in the right direction. In puzzle and problem solving experiments, false orientation is often a major difficulty. The subject begins work under a false assumption and labors assiduously to advance in an impossible direction. In spite of repeated failures he sometimes clings obstinately to his false lead, as if his self-assertion would be wounded by backing off and making a fresh start.

Psychology and Logic; the syllogism. Psychology is not the only science that studies reasoning; logic was in the field long before psychology. Psychology studies the *process* of reasoning, while logic checks up the result and shows whether it is valid. Logic cares nothing about the exploratory process that culminates in inference, but limits itself to inference alone.

Inference, in logical terminology, consists in drawing a conclusion from two given premises. The premises are the data which, acting together, arouse the response of seeing or inferring the conclusion. The two premises and the conclusion, set forth in order, constitute the syllogism, as in the example:

All mammals are warm-blooded;
All bears are mammals;
Therefore, all bears are warm-blooded.

The conclusion is inferred, or seen to be implied in the two premises taken together.

Difficulties in syllogistic reasoning. The example just given can be called an extremely plain syllogism; many examples are much more difficult to grasp. Since they present difficulties, and since they call not for preliminary exploration of the field but for the critical act of inference, they can be profitably used as problems in an experiment to discover the difficulties of inference. The premises of a syllogism are given to children, and the age level of this particular problem is determined (1, 2). By this means various problems are compared and certain sources of difficulty are discovered. Lack of familiarity with the topic of a problem is one obvious cause of failure to reason freely and surely. Another cause lies in an excessive amount of material to be put together in reaching a conclusion. Especially confusing is the presence of irrelevant data which have to be thrust aside before the pattern of the real data can take shape. Irrelevant data are, however, always to be expected in any problem of actual life.

Another source of difficulty is the confused arrangement in which the data usually present themselves. They have to be rearranged by the reasoner before the conclusion can be seen in the pattern of the data. An instance is afforded by the efforts of eight-year-old children to solve the following problem:

> Edith is fairer than Olive; but she is darker than Lily.
> Who is darker, Olive or Lily?

In this form the problem was solved correctly by only 46 percent of the 8-year group; but the percent of successes rose to 72 when a simple linguistic change was made, giving the same problem this form:

> Lily is fairer than Edith; Edith is fairer than Olive.
> Who is the fairest, Lily or Olive?

The difficulty with the first form was that the child found it necessary to turn the first premise around into "Olive is darker than Edith," before he could see the answer. The second form runs straight along, while the first form jerks back and forth because of the use of the two opposite relationship words, "fairer" and "darker." Changing the order of the two premises may affect the difficulty of the syllogism.

Difficulty arises from another source that would not be suspected. If the conclusion is known to be true or false as a matter of fact, there is difficulty in seeing whether or not it follows from the given premises. Notice the following reasoning:

> All Mongolians have slant eyes.
> The Chinese have slant eyes.
> Therefore, the Chinese are Mongolians.

Over 50 percent of a group of college students marked this conclusion as correct. They would doubtless have responded quite differently to the same syllogism with changed terms, as for example,

> All birds have wings.
> Bees have wings.
> Therefore, bees are birds.

To escape from such confusing associations and pin oneself down to the data and their pattern, letters can be substituted for the meaningful terms of a syllogism. In place of either of the two just given, we should have

All A is B.
C is B
Therefore, C is A.

But this device, though useful to some individuals, especially after practice, is on the whole rather a hindrance than a help to the uninitiated. Even college students, with all their training in algebra and other formulae, commit more errors in these symbolic syllogisms than in those stated in ordinary language. They made, in one extensive experiment, 16 percent of errors in dealing with syllogisms expressed in familiar terms, as against 24 percent when exactly the same syllogisms were given in letter symbols (13).

Overcoming the difficulties of inference. Introspective experiments reveal various devices by which the subject reduces the premises to order, or builds them into a pattern from which he can read off the conclusion (11). The devices most in evidence are the following.

Gestures and feelings of bodily movement.

Diagrams. The subject builds up a pattern of a spatial sort. In one case the problem as presented was:

Q is to the right of M;
G is to the right of Q.
Therefore, ...

And the subject's report:

> Q was localized to the right of M; G was then localized to the right of this Q, so that there was an imaginary row, M . . . Q . . . G, from which pattern the fact was read off that G is to the right of M.

Verbal patterns. Here the premises are combined into one synthetic statement from which the conclusion can be "lifted." An example:

Many J belong to the class F;
All F belong to the class D.
Therefore, ...

The subject's report:

> The second premise was expanded to take in the first, thus: "All F, including the many J, belong to class D." Therefore, many J belong to class D.

Another example:

If P does not exist, R does not exist;
Only if V exists does P exist.
Therefore, ...

On which the subject reported:

> After many false leads I started with the second premise and modified it to read, "If V does not exist, neither does P" — that is the force of the "only." Aha! Now I can put them together nicely: If V does not exist, P does not exist; and if P does exist, R does not exist. Therefore, if V does not exist, R does not exist.

The "Aha!" in this report signalizes a moment of insight, the exact moment when inference occurred. Such "Aha! experiences" are frequently reported in studies of reasoning.

Overcoming linguistic difficulties in reasoning. In these syllogism experiments, a large share of the difficulty arises from the fact that ordinary language is not well suited to present the exact data nor to formulate the pattern into which the data have to be thrown. This source of difficulty appears clearly when the problem involves only a single statement and asks what can be made out of that statement besides what is directly stated. Can the statement be "converted" by interchanging subject and predicate? If "Some X is Y," can we infer that some Y is X? Yes. If "No X is Y" can we infer that no Y is X? Yes. But if "All X is Y," we cannot infer that all Y is X, but only that some Y is X. And if "Some X is not Y," we cannot infer anything at all. The difficulty here is one of language. "All X is Y" has an atmosphere of strong assertion which misleads one into making the strong converse statement; and "Some X is not Y" has an atmosphere of weak negation which we tend to carry over to the converse. The majority of students fall into both of these errors.

"All X is Y" is an ambiguous statement. It may mean that the class X is identical with the class Y, or that the class X is included within the class Y. In the one case it can be strictly converted, but in the other all we can infer is that *some* Y is X. If we represent the inclusion of class X in class Y by a diagram, no one would be in any doubt as to what could be inferred.

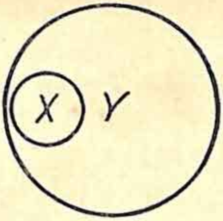


FIG. 108

Overlapping classes are still less well stated in our ordinary forms of speech. Consider the following diagram:

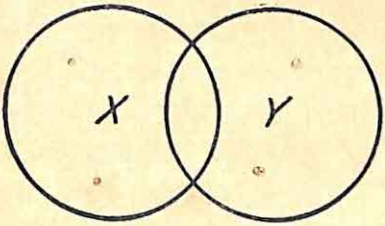


FIG. 109

It takes three ordinary statements to express the facts represented in this diagram: Some X is Y, Some X is not Y, Some Y is not X. But the diagram makes everything clear in an instant. Such diagrams are used in teaching logic to overcome the difficulties of linguistic expression.

Motivation of reasoning. There must be some motive to induce anyone to engage in this rather strenuous mental process, but the situation and the motive differ from one case to another, falling however into a few main classes.

1. Solution of a practical problem. Here we start not with given premises but with a particular situation which has to be met. The necessary premises have to be found. We observe facts in the situation which recall previous experiences or previously learned rules and principles. Thus we assemble the necessary data along with much that is irrelevant, and we fit the data together into one pattern after another until we find one that meets the situation.

2. Rationalization or self-justification. While in the preceding case reasoning showed what to do, here it is called upon to justify what has been done. The question is, what reason to assign for our act; we feel the need of meeting criticism, either from other people or from ourselves. The real motive for the act may be unknown to ourselves, as it often is unless we have made a careful study of motives; or, if known, it may not be such as we care to confess. We require a *reasonable* motive, some acceptable general principle that explains our action; and we usually succeed in finding one.

3. Explanation. This form of reasoning, like the preceding, takes its start with something that raises the question, "Why?" Only, our interest in the question is objective rather than subjective. It is not our own actions that call for explanation, but some fact of nature or of human behavior. To explain a phenomenon is to find some general principle from which it can be inferred or deduced, and such explanation is very agreeable, since it rids us of uncertainty and sometimes of fear, and gives a sense of power and mastery.

4. Application. While the reasoning processes thus far discussed have taken their start with the particular case and hunted for a general principle to fit the case, reasoning may also take its start at the other end. It may start from the general principle and seek for particular cases belonging under it. But what can be the motive for this sort of reasoning? What is there about a general proposition to stimulate exploration?

The motive may be that of seeing the application of the principle. Somebody whose authority you fully accept enunciates a principle, and you wish to see how it applies to particular cases; you may have hopes of putting it to practical use, or you may simply wish to clarify its meaning. You search your memory for concrete instances where the accepted principle should apply. If the general proposition is that birds and mammals are the only warm-blooded animals, then fish, frogs and lizards are cold-blooded; also spiders, insects, lobsters and worms; these inferences give you a more realistic understanding of the general proposition.

Under the head of application belongs *prediction*. The general principle, applied to a particular situation, enables you to predict the outcome of the situation. Thus the astronomer successfully predicts eclipses, the physician the course of a fever and the results to be expected from a certain treatment, and the engineer the strength of his bridge or the current to be produced by his dynamo. Prediction is a step towards control, so that there is plenty of motivation for this type of reasoning.

5. Doubt. A general proposition may stimulate reasoning because you doubt it and wish to find cases where it breaks down. Perhaps somebody makes the general statement whose authority you do not accept; perhaps he says it in an assertive way that makes you want to take him down a peg. Perhaps

This common experience, along with the fact that man, the thinking animal, is also the talking animal, had led to the identification of thought with inner speech.

Language is certainly a great aid to thought. First and most important, thinking develops very largely out of *social* behavior. The child is stimulated to think by being spoken to and by his desire to explain his wants to other people. Discussion and argument stimulate thought, and even when the individual is thinking alone he is apt to have a social situation in the back of his mind and to be preparing to defend his conclusions.

Language is an aid in assembling materials for thought, because it is an aid in *recall*. Verbalized facts and principles are more readily recalled. If you formulate in words the principles found useful in solving one problem, you recall them more surely when you encounter a similar problem. A good stock of carefully formulated principles is essential for efficient reasoning in any difficult field.

Language is a system of *symbols* which can be substituted for facts and which can be manipulated more handily than the facts. Words not only aid thought, but also save thought. Number words are the best illustration here. By knowing the meaning of the number words, by learning the addition and multiplication tables — jingles of words, to a large extent — and by following certain set rules of procedure, we are able to figure out number problems with a facility that is marvellous. Mathematics, as a whole, is the greatest achievement of human reasoning, and depends mostly on the use of symbols. These symbols, to be sure, are not wholly linguistic, since, though most of them have names, they are more essentially written characters, and few people can follow a mathematical process of reasoning that is conducted orally, without any aid from the eye. This instance leads us to suspect that thinking is just as much seeing as it is talking.

In spite of all that can be said in its favor, the thesis that thought = inner speech is probably wrong. In syllogistic reasoning, as we saw, language is in some respects a definite handicap to clear thinking. Because of the inadequacy and deceptiveness of the verbal forms, resort is had to diagrams. The mathematician resorts to symbols which are combined on another system than the rules of syntax. The geographer thinks in terms of maps, and the engineer in terms of blue prints, which are symbols indeed, but symbols put together according to the nature of the objective facts which they symbolize, and not according to the rules of language. Thought in any field has to adapt itself to the realities of that field, and cannot impose on the facts the peculiarities of language. Thought is based on observation of facts more than on language.

Introspection, which certainly supports the proposition that much inner speech goes on in thinking, also shows that at certain times thought runs away from speech. When thought is very active, speech is apt to become fragmentary. At moments of insight, speech may be reduced to " Aha! " Here are a few other facts indicating that thought cannot be identified with inner speech. You often think of an object without bothering to recall its name. Silent reading covers a page in half the time that would be required for pronouncing the words, however rapidly. In reading aloud, you get the sense of a word before the voice reaches that word, and so can give the thought proper expression. In speaking also, thought keeps ahead of the speech organs, so that you are thinking one thing while saying another. Thought, from all the indications, precedes speech and is not identical with it.

Talking does not insure thinking — that is certain. To say the words in which a thought is expressed is not sufficient. A boy learns his little speech thoroughly, goes on the platform and rattles if off without the slightest sense of what he is saying. One can repeat a pregnant phrase over and over indefinitely, but soon ceases to *think* it. If we were justified in writing any equation between thought and speech, the equation would have to read, not thought = speech, but thought = meaningful speech. Language is a system of signs, and thought deals with the meanings of the signs.

Thought and the muscles. It is quite another question, though a question of much theoretical interest, whether thinking can go on without any muscular activity. Is it possible for cerebral activity to occur without any discharge into the muscles? And if the muscles are active, can we assume that their activity has nothing to do with the process of thinking itself? It may be that thinking should be regarded as an activity of the organism, muscles included, rather than purely a brain activity.

Recording apparatus applied to the tongue and larynx reveals little movements occurring much of the time, during active thought or otherwise, but does not show what might be expected. One might expect to find, during inner speech, movements like those of whispering, only smaller, but the movements which occur in inner speech do not clearly show the pattern of speech movements (12). When, however, an electrode is inserted directly into the tongue muscle, so as to lead off the "action currents" of the muscle to a galvanometer, it is found that these little electric currents, which always occur in an acting muscle, do occur when the individual silently counts "One, two, three," in much the same way as in audible counting, but more weakly. Action currents appear in the tongue when the individual silently repeats a poem. The mental activity must, however, involve words or numbers in order to produce action currents in the tongue. If an arm movement is imagined, there are action currents in the arm muscles.

Two inferences can perhaps be drawn. First, thinking is commonly accompanied by muscular activity, though not exclusively by activity of the speech organs. Second, the muscular activity in thought is commonly so much reduced in intensity as to require very delicate instruments for its detection (6).

CONCEPTS AND THEIR DEVELOPMENT

An important tool in thinking is the concept, which in more familiar language is the idea you have of anything. It is not any single memory image or motor response. Rather, the concept is the sum total of what you know about the object: how it looks, how it sounds, how it smells, tastes and feels to you, what it does and what you do to it. Your concept of anything is what the thing means to you. Anything that can be perceived by the senses, thought of or imagined, can be conceived — persons, things, events, qualities and relations, concrete or abstract, individual or general.

To be a tool of thought, a concept needs to have some unity. The various items included in it need to be linked together by observation of their all belonging to the same object. The responses you make to the object must have come to your attention. The concept of air, for example, is a difficult one for the child to form, though he deals with the air from the moment of birth, inhaling and exhaling it, operating his vocal cords with it, and doubtless feeling it pass through his throat. Air in motion, air that feels cold or that makes a noise, he knows when two or three years old, but the notion of quiet air, filling the room, and breathed in and out, he does not get till several years later. He needs to know still air before he can tie up the wind and his own breathing into a single concept.

Development of concepts in the little child. Until the child can talk, it is difficult to trace the development of his concepts, though he probably does some thinking and forms some concepts before he begins to talk. Very early he responds to the sight of a person by getting ready for what the person usually does to him, and as soon as he definitely *anticipates* what the person will do, he certainly has a rudimentary concept of that person. And so of things. As soon as he definitely anticipates the noise a spoon will make when dropped on the floor, he knows something about spoons and has a rudimentary concept of that class of objects. Therefore the child's behavior, even before he starts to talk, strongly suggests that he is already building up concepts. The child's concept of a thing centers around what he does with the thing and what it does to him.

When the child begins to understand words, and soon afterwards to say them, he is picking up the concepts current in his social environment, and we can judge, from his growing vocabulary, which of these concepts he acquires most readily. We note two factors of advantage in this early development of concepts. What stands out in sense perception has an advantage in concept formation, and what the child deals with in a practical way has the advantage.

Further development of the child's concepts. Interesting studies of children's concepts of the physical world, between the ages of three and twelve, have been made by listening to their questions, by demonstrating physical phenomena and by quizzing the children (5, 8). There seem to be two streams of the child's thought on physical matters, an animistic stream and a realistic or mechanistic stream. Animistically, he reads something akin to his own desires, or something akin to the doings of men, into natural phenomena that are outside of his own field of practical activity. Realistically, within the field of his activity, he learns the common properties of physical objects, such as weight and friction, and accepts them as matters-of-course that require no explanation. When children of different ages are asked what things are alive and can feel, their answers indicate a gradual development from animistic to more mechanistic conceptions of nature, passing through a series of stages which however are not closely bound up with definite ages, since some children progress in this respect much faster than others.

In the first stage, everything is alive and can feel:

Does a stone feel the cold? *No.* — Would it feel if it was dropped on the ground? *Yes, because it would break.* — Can a table feel anything? *No.* — Would it feel if it were being broken? *Oh, yes.* — Does the wind feel when it blows against a house? *Yes, because it is in its way. It can't pass. It can't go any further.* — Do walls feel? *No.* Why not? *Because they can't move.* Would they feel anything if they were knocked down? *Yes.*

In the second stage, anything can feel when it moves:

Does the sun know anything? *Yes, it heats.* — Does it know that it's hidden from us in the evening? *Yes, because it sees the clouds in front of it. . . . no, it doesn't know, because it isn't the sun that hides. It's the clouds that go in front of it.* — Does a bicycle know when it goes? *Yes, it feels the ground.* — Does a motor know it goes? *Yes, it feels it isn't still in the same place.*

In the third stage, things feel when they move *of themselves:*

Is a fly alive? *Yes, because if it wasn't alive it couldn't fly.*

Is a bicycle alive? *No, because it's we who make it go.*

Are clouds alive? *Yes — no, they're not. If they were alive, they would come and go as they wanted. It's the wind that drives them.*

Is the wind alive? *Yes, because it's the wind that drives the clouds.*

Are streams alive? *Yes, because the water is flowing all the time.*

Is an automobile alive? *No, it's the engine that makes it go.*

Is the engine alive? *No, it's man who makes the engine go.*

Is the sun alive? *Yes, it makes the sunshine and gives light.*

A further stage would be a mechanistic conception of the movements of all inanimate things, and this is about as far as most individuals go in this direction.

Egocentric and objective concepts. The difficulties with which the child labors in reaching objective concepts are well illustrated in the case of the apparent motion of the sun or moon. The child sees the sun or moon move with him when what the person will do, he certainly has a rudimentary concept of that person. And so of things. As soon as he definitely anticipates the noise a spoon will make when dropped on the floor, he knows something about spoons and has a rudimentary concept of that class of objects. Therefore the child's behavior, even before he starts to talk, strongly suggests that he is already building up concepts. The child's concept of a thing centers around what he does with the thing and what it does to him.

When the child begins to understand words, and soon afterwards to say them, he is picking up the concepts current in his social environment, and we can judge, from his growing vocabulary, which of these concepts he acquires most readily. We note two factors of advantage in this early development of concepts. What stands out in sense perception has an advantage in concept formation, and what the child deals with in a practical way has the advantage.

Further development of the child's concepts. Interesting studies of children's concepts of the physical world, between the ages of three and twelve, have been made by listening to their questions, by demonstrating physical phenomena and by quizzing the children (5, 8). There seem to be two streams of the child's thought on physical matters, an animistic stream and a realistic or mechanistic stream. Animistically, he reads something akin to his own desires, or something akin to the doings of men, into natural phenomena that are outside of his own field of practical activity. Realistically, within the field of his activity, he learns the common properties of physical objects, such as weight and friction, and accepts them as matters-of-course that require no explanation. When children of different ages are asked what things are alive and can feel, their answers indicate a gradual development from animistic to more mechanistic conceptions of nature, passing through a series of stages which however are not closely bound up with definite ages, since some children progress in this respect much faster than others.

In the first stage, everything is alive and can feel:

Does a stone feel the cold? *No.* — Would it feel if it was dropped on the ground? *Yes, because it would break.* — Can a table feel anything? *No.* — Would it feel if it were being broken? *Oh, yes.* — Does the wind feel when it blows against a house? *Yes, because it is in its way. It can't pass. It can't go any further.* — Do walls feel? *No.* Why not? *Because they can't move.* Would they feel anything if they were knocked down? *Yes.*

In the second stage, anything can feel when it moves:

Does the sun know anything? *Yes, it heats.* — Does it know that it's hidden from us in the evening? *Yes, because it sees the clouds in front of it. . . . no, it doesn't know, because it isn't the sun that hides. It's the clouds that go in front of it.* — Does a bicycle know when it goes? *Yes, it feels the ground.* — Does a motor know it goes? *Yes, it feels it isn't still in the same place.*

In the third stage, things feel when they move *of themselves:*

Is a fly alive? *Yes, because if it wasn't alive it couldn't fly.*
Is a bicycle alive? *No, because it's we who make it go.*
Are clouds alive? *Yes — no, they're not. If they were alive, they would come and go as they wanted. It's the wind that drives them.*
Is the wind alive? *Yes, because it's the wind that drives the clouds.*
Are streams alive? *Yes, because the water is flowing all the time.*
Is an automobile alive? *No, it's the engine that makes it go.*
Is the engine alive? *No, it's man who makes the engine go.*
Is the sun alive? *Yes, it makes the sunshine and gives light.*

A further stage would be a mechanistic conception of the movements of all inanimate things, and this is about as far as most individuals go in this direction.

Egocentric and objective concepts. The difficulties with which the child labors in reaching objective concepts are well illustrated in the case of the apparent motion of the sun or moon. The child sees the sun or moon move with him when he walks. It seems that he makes them move, or else that they follow him. This "egocentric" concept is flattering, and is also the easiest and most direct reading of the observed facts. The child has the same difficulties, in a small way, that the whole civilized world had about 1600 in giving up the man-flattering and obvious geocentric conception of the universe for the Copernican conception. It takes a wrench to conceive of the earth as being not the center of all things but only a small element in a much bigger system.

The individual's own dealing with things necessarily centers in himself, and to conceive of things as centered anywhere else, or as not centered at all, seems to him at first utterly unpractical, though the objective concepts obtained by thinking from some other center than oneself are often extremely practical in the long run. The child is early forced to get beyond himself in his conceptions of objects. A ball may be to him at first just "something to throw," but after it has left his hands he sees it roll and bounce. Some one else picks it up and will not give it to him, and he sees balls in the store that he "mustn't touch." So he is led, and driven, to an objective conception of a ball as having certain properties independent of him. An egocentric concept is one which relates the object to the individual himself, while an objective concept relates one object to another. The child is led and forced to observe things acting upon each other, or otherwise related to each other, and so makes a start in the formation of objective concepts.

The concept, to be a tool of successful thinking, has to "work." It has to work in the manipulation of objects, and is checked up by the physical environment; and it has to work in conversation with other people, and is checked up by the social environment. The physical environment insists on objectivity of concepts, and the social environment insists on their conformity with the accepted ideas of the group. By degrees, then, some of the child's concepts become objective, while others come to accord with the concepts of the culture in which he is growing up. These socially accepted concepts are often far from objective; in many cultures, for instance, animistic views of many natural phenomena are standard.

Generalization of concepts. Since what is observed is always some particular ball or dog or person, the question arises how the child ever comes to his concepts of a class of objects — balls, dogs or persons in general. We might suspect that it would be a slow and difficult process for him to advance from concepts of this, that and the other particular dog to the concept of dogs as a class. But to quite an extent generalizing is the line of least resistance. The child's spontaneous extension of the meaning of names reveals the ease with which he generalizes. He calls a strange man "papa"; the first time he sees a squirrel, he calls it a "funny kitty." He reacts to the new object as he has learned to react to similar objects. It is a case of reduced cues, again: the new stimulus has enough in common with the old to arouse the same response. When a certain response has worked well in one case, it is apt to be made in a similar case, and some environmental check in the form of failure or ridicule is needed to break up the broad class of objects into sub-classes. Such is generalization of the practical sort, but to reach an intellectual generalization, a real concept of the class of objects, some freedom of thought, some separation from motor response, is necessary.

A start towards this freedom is seen in what is called *association by similarity*. One thing makes you think of another similar thing that you have known. One person reminds you of another. Now if, on sight of a person who resembles your old friend, you impulsively rush up and grasp his hand, only to be received with wonder, that is simply a response to a reduced cue. But if you check your motor response and say to yourself that this stranger resembles your friend, that is association by similarity — a more complex response, since you are thinking of two people instead of only one, and since you are aware of some difference between them as well as of their resemblance. Association by similarity explicitly recognizes the likeness of objects that are not identical, and so leads to the concept of a class of similar objects. But another step, and a long one, is necessary before you can define this class, or before you see exactly in what respect the objects are similar. Analysis is necessary.

Analysis and definition. To define a concept, you must discover what is common to all objects covered by the concept, without being present in other objects that do not belong under the concept. A chair is "to sit on," but you can sit on other things. Chairs themselves vary in many ways, and any one chair has characteristics that do not belong in the concept of a chair. The difficulty is to peel off from a chair, in thought, something that does not come off physically, namely, the essential characteristics of a chair. It is a task of isolation.

Two procedures are theoretically possible by which this isolation could be accomplished. One has been called *isolation by varying concomitants*, and might also be called, by a figure of speech, the "composite photography" process. The other may be called the method of *hypothesis and verification*, and is a form of the trial and error process.

In taking a composite photograph of ten persons, you expose the plate one tenth of the usual time for each successive individual, taking care to superimpose the faces as closely as possible. The composite shows a face with the common characteristics emphasized and the individual variations mostly lost. By analogy we can imagine an observer viewing one specimen after another of a given class of objects and finally obtaining a generalized memory image. The common features would come out strongly by virtue of frequency, and the varying concomitants would have little effect on the composite picture. Without assuming a clear visual memory image, we can at least suppose that the observer would gradually build up a response to the common features of the varying objects of the same class.

The trial and error process would be essentially the same as described a few pages back under the head of "verification." The observer tries out his first rough concept and keeps it as long as it holds good, but is often forced to modify it or drop it and try another lead, just as in ordinary problem solution or as in scientific investigation.

The concept-forming experiment. This is a learning experiment with the peculiarity that the situation does not remain constant in all respects. It presents "identity in difference," and the question is whether the subject can learn to respond to the identity in spite of the difference. Can the white rat learn to go to a door marked by a triangle, in spite of variations in the size and position of the triangle? First he is trained to respond positively to a white equilateral triangle in the upright position (one angle at the top) and negatively to a white circle of the same area, the remainder of the visible field being black. When this discrimination is well established, the triangle is presented in different sizes and positions. His positive response to the triangle is somewhat disturbed, but comparatively few trials are needed before he responds correctly to each new size or position. After many variations have been learned, very little new learning is necessary with further variations. It is clear from this carry-over or transfer effect that the rat is not simply learning to respond to each new position as a separate performance. The negative figure, at first a circle, is changed from time to time, to make sure that the animal is not simply making an avoiding response (3).

The main result of this experiment with rats is the demonstration that the concept-response is possible for this animal. He can learn, given sufficient opportunity, to respond to the common character of all white triangles on a black ground.

When the apparatus was changed so as to present a black triangle and circle in a large white field, new training was necessary, but less than at first; and the acquisition of this new response did not break down the previously acquired response to white triangles.

The behavior of the animals during the concept-forming process indicates that they work by observation. They examine the two objects deliberately before making their decision. Also, they react with some consistency for a number of trials, as if following a rule. If this rule does not work they seem to try another (7).

Experiments of the same general plan have been tried with human subjects who have the advantage of being informed from the start that something common is to be found in a series of varying objects. Of course, the human subject is able to work out general concepts; but the question is how he proceeds.

He proceeds by hypotheses and verification. At least, this procedure is the one that stands out clearly. Let us suppose that the experimenter has prepared a series of nonsense drawings which conform to a certain definition by all possessing certain characters but which have other features in which they are not all alike. A nonsense name is assigned to this class of drawings, and there are one or more other classes each with its nonsense name. The subject's task is to observe the drawings as they are shown in succession and to evolve a definition of each class. In the first drawing seen the subject becomes aware of some prominent feature and this is immediately seized upon if it is present in the second drawing; it continues to be noticed clearly if present in the following drawings and to be searched for if inconspicuous. If the feature in question is found to be certainly absent from one or more of the drawings, it lapses from the field of attention. Other features are noted as the series advances and are subjected to the same sort of scrutiny (4, 9, 10).

Though the trial and error process is clearly present, the question remains how the hypotheses themselves arise. There is a good chance that they may arise by the summation of impressions from the common features. If so, isolation by varying concomitants plays a rather important role in the whole activity, even though the more active procedure of verification of trial concepts must be depended on for definite achievement.

REFERENCES

1. Burt, C. "The development of reasoning in school children." *J. Exper. Ped.*, 1919, 5, 68–77; 121–127.

2. Burt, C. *Mental and scholastic tests.* 1921.

3. Fields, P. E. "Studies in concept formation." *Comp. Psychol. Monog.*, 1932, 9, No. 2.

4. Fisher, S. C. "The process of generalizing abstraction, . . ." *Psychol. Monog.*, 1916, 21.

5. Huang, I. "Children's explanations of strange phenomena." *Psychol. Forsch.*, 1930, 14, 63–182.

6. Jacobson, E. "Electrophysiology of mental activities." *Amer. J. Psychol.*, 1932, 44, 677–694.

7. Krechevsky, I. "Hypotheses versus chance in the pre-solution period, . . ." *Cal. Pub. Psychol.*, 1932, 6, 27–64.

8. Piaget, J. *The child's conception of the world.* 1929.

9. Smoke, K. L. "An objective study of concept formation." *Psychol. Monog.*, 1932, 42.

10. Stevanović, B. P. "An experimental study of the mental processes involved in judgment." *Brit. J. Psychol. Monog.*, 1927, No. 12.

11. Störring, G. *Das urteilende und schliessende Denken in causale Behandlung.* 1926.

12. Thorson, A. M. "The relation of tongue movements to internal speech." *J. Exper. Psychol.*, 1925, 8, 1–32.

13. Wilkins, M. C. "Effect of material on formal syllogistic reasoning." *Arch. Psychol.*, 1928.

CHAPTER XVIII

IMAGINATION

From discovery we now turn to invention, from exploration to manipulation.

The human enterprise of exploration, which we have been examining, runs the gamut from simple movements of looking and listening to the elaborate procedure of science in testing hypotheses and discovering laws of nature. Inventive activity runs a similar gamut from the child's play with his toys to the creation of a work of art or engineering or the organization of a new form of government. The distinction between the two lines of activity is that exploration seeks facts as they are, and manipulation aims at some change. The two enterprises go hand in hand, however; invention is based on science and science no less on invention.

For a preliminary, catch-word type of definition, we may say that imagination is *mental manipulation.* When the individual recalls facts previously observed in reality and then proceeds to rearrange these facts into a new pattern, he is said to show imagination. A product of imagination is composed of parts perceived at different times and later recalled and combined, as a centaur is composed of man and horse, and a mermaid of woman and fish. Imagination is like reasoning in using recalled facts; but while reasoning consists in seeing relations actually existing between the facts, imagination puts them into new relations.

Imagination and invention are much the same, though imagination means rather the mental process itself, and invention often the outcome of the process, which is a product having some degree of novelty and originality.

Imagination, like association, is sometimes free, and sometimes controlled. Controlled imagination is directed towards the accomplishment of some desired result, while free imagination wanders this way and that, with no fixed aim. Controlled imagination is seen in planning and designing; free imagination occurs in moments of relaxation, and may be called "play of the imagination." The playful sort of imagination is probably the more fundamental and the first to develop, and we may therefore assist ourselves towards an understanding of imagination by devoting some attention to play.

IMAGINATIVE PLAY

Manipulation and exploration certainly go hand in hand in the little child's play. The baby picks up his new toy, turns it about and examines it on all sides, shakes it and is pleased if it makes a noise, drops it and is pleased with its bang on the floor. In manipulating the toy he is exploring it and learning its properties.

Beginnings of imagination in the child. Beginning with grasping, turning, shaking and dropping of objects, the child's manipulation develops in several directions. One line of development leads to *manual skill.* Skilled movement develops out of the miscellaneous movements of play rather than by the combination of definite reflexes.

A second line of development is in the direction of *constructiveness.* Taking things apart and putting them together, building blocks, assembling dolls into "parties," are examples of this style of manipulation, which calls less for manual dexterity than for seeing ways in which objects can be rearranged.

Make-believe is a third direction followed in the development of manipulation. The little boy puts together a row of blocks and pushes it along the floor, asserting that it is a train of cars. The little girl lays her doll carefully in its bed, saying "My baby's sick; that big dog did bite him." This amounts to manipulating things according to the *meanings* attached to them, the blocks being treated as cars, and the doll as a sick baby.

Perhaps a little later than make-believe to make its appearance in the child is *story-telling,* the fourth type of manipulation. (4) Where in make-believe he has an actual object to manipulate, in story-telling he simply talks about persons and things and makes them perform in his story. He comes breathless into the house with a harrowing tale of being pursued by a hippopotamus in the woods; or he gives a fantastic account of the doings of his acquaintances. For this he is accused of being a "little liar," or more charitably described as unable to distinguish observation from imagination; but really what he has not yet grasped is the *social* difference between his make-believe, which no one objects to, and his story-telling, which may lead people astray (p. 129).

In such ways as we have been describing, the little child shows imagination or mental manipulation. In story-telling the objects manipulated are simply *thought of;* in make-believe, though there is motor manipulation of present objects, the attached *meanings* are the important matter; and in construction there is apt to be a *plan* in mind in advance of the motor manipulation. Thus play, usually if not always, contains an element of imagination. We may take the child's play as the first and simplest case of free invention and ask (a) what objects are suited to arouse playful activity, (b) in what the activity consists and what results it reaches, and (c) what may be its motivation.

Playthings. What, after all, is a toy? What characteristics of an object make it a real toy, which shall actually arouse the play response? We can approach this question empirically by assembling a list of toys, and classifying them from the psychological point of view. A large share of them fall into the following classes.

Movable objects: a book, door or drawer to open and shut, a water tap to turn on and off (especially on), a bag or box to pack and unpack. Almost anything that the child can move serves him as a plaything.

Plastic materials: damp sand, mud, snow; and other materials that can be worked in some way, as paper to tear or fold, blocks to pile or build, water to pour.

Noise-makers: rattle, drum, bell, horn, firecracker.

Vehicles, especially those providing unusual modes of locomotion: cart, bicycle, sled, skates, skipping-rope.

Space-annihilators enabling the child to act at a distance: balls to throw, bow and arrow, sling, mirror to flash light into the eyes of a distant person.

Things that defy gravity by floating, balancing or rising instead of falling: balloon, kite, boat, top, rolling hoop, swing, seesaw.

Adult-imitating toys: little tools, dishes, furniture, toy animals, dolls. Some psychologists have been so much impressed with the imitative play of children and animals (as illustrated by puppies playing fight), that they have conceived of all play as a sort of rehearsal for the serious business of life; but this conception does not apply very well to the other sorts of toy.

The play response. Play consists in manipulating or managing the plaything so as to produce some interesting result. The hoop is made to roll, the kite to fly, the arrow to hit something at a distance, the blocks are built into a tower or knocked down with a crash, the mud is made into a "pie," the horn is sounded. Many games are variations on pursuit and capture (or escape): tag, hide-and-seek, prisoner's base, blindman's buff, football. Wrestling, boxing, snowballing are variations on attack and defense. Action at a distance appears in golf, croquet, bowling, quoits, billiards, shooting. The element of manual skill enters into nearly all games. Mental acuteness appears in the guessing games, as well as in chess and cards. Many games combine several of the elements mentioned, as in baseball we have action at a distance, pursuit and escape, motor skill and activity, and a chance for "head work."

The play motives. No single "play instinct" furnishes all the motivation, but many sources of satisfaction are tapped. In the games that imitate fighting, some of the joy of fighting is experienced, even though no real anger develops. In the games that imitate pursuit and escape, some of the joy of hunting and some of the joy of escape are awakened. In the kissing games that used to be common in young people's parties when dancing was frowned upon, and in dancing itself, sex gratification is present; but dancing also gives a chance for muscular activity which is obviously one source of satisfaction in the more active games. In fact, joy in motor activity must be counted as one of the most general sources of play-satisfaction. Another general element is the love of social activity, which we see in dancing as well as in nearly all games and sports.

The "escape motive" deserves a little more notice. Though you would say at first thought that no one could seek fear, and that this emotion could not possibly be utilized in play, yet a great many amusements are based on fear. The chutes, scenic railways, roller coasters, etc., of the amusement parks would have no attraction if they had no thrill; and the thrill means fear. You get some of the thrill of danger, though you know that the danger is not very real. Probably the thrill itself would not be worth much, but being quickly followed by *escape*, it is highly satisfactory. The joy of escape more than pays for the momentary unpleasantness of fear. Fear is utilized also in coasting on the snow, climbing, swimming, or any adventurous sport: in all of them there is danger, but the skilful player escapes by his own efforts. If he lost control he would get a tumble; and that is why the sport is exciting and worth while. Nothing could be much further from the truth than to consider fear as a purely negative thing, having no positive contribution to make to human satisfaction. The fascination of gambling and of taking various risks probably comes from the satisfaction of the fear and escape motive.

But of all the "unlearned motives," it is *self-assertion or mastery* that comes in oftenest. Competition, one form of self-assertion, is utilized in a tremendous number of games and sports. Either the players compete as individuals, or they choose sides and compete as teams. No one can deny that the joy of winning is the high light of play. Yet it is not the whole thing, for the game may have been worth while, even if you lose. Provided you can say, "Though I did not win, I played a good game," you have the satisfaction of having done well, which is the mastery satisfaction in its non-competitive form.

All toys that enable you to act at a distance, or to move rapidly, gratify the mastery impulse. Imitative play does the same, in that it enables the child to perform, in make-believe, the important deeds of adults. Children like to play at being grown-up, whether by wearing long dresses or by smoking, and you can observe how important they feel by the way they strut and swagger.

Empathy. There is still another *possible* way in which play may gratify the mastery impulse. Why do we like to see a kite flying? Of course, if it is *our* kite and we are flying it, the mastery impulse is directly aroused and gratified; but we also like to watch a kite flown by some one else, and similarly we like to watch a hawk, a balloon or aëroplane, a rocket. We like also to watch things that balance or float or in other ways seem to be superior to the force of gravity. Why should such things fascinate us? Perhaps because of *empathy*, the "feeling oneself into" the object contemplated. As sympathy means "feeling with," empathy means "feeling into," and the idea is that the observer projects himself into the object observed, and gets some of the satisfaction from watching an object that he would get from *being* that object. Would it not be grand to be a kite, would it not be masterful? Here we stand, slaves of the force of gravity, sometimes toying with it for a moment when we take a dive or a coast, at other times having to struggle against it for our very lives, and all the time bound and limited by it — while the kite soars aloft in apparent defiance of all such laws and limitations. Of course it fascinates us, since watching it gives us, by empathy, some of the sense of power and freedom that seems appropriate to the behavior of a kite. Perhaps the fascination of fire is empathy of a similar sort; for fire is power. Empathy must be regarded as a hypothesis, rather than as a proved fact.

Play as self-motivating activity. Play gives rise to situations that are interesting and attractive to the players, even when the attraction cannot be traced to the "unlearned motives." The rhythm of dancing, marching, and of children's sing-song games can scarcely be traced to any of them. The sociability of games goes beyond mere gregariousness, since it calls for acting together and not simply for being together; and at the same time it goes beyond competition and self-assertion, as is seen in the satisfaction the players derive from good team work.

If the self-assertive impulse of an individual player is too strongly aroused, he spoils the game, just as an angry player spoils a friendly wrestling match or snowball fight, and just as a thoroughly frightened passenger spoils a trip down the rapids, which was meant to be simply thrilling. Though the emotions and fundamental motives of life are active in play, they must not be too active. (A game is a complex activity, carried on at a relatively high level, and furnishing its own interest and its own motivation, just as other human activities do.) A motive, we remember, is an activity in progress, and any complex activity, once the individual is fully embarked upon it, furnishes its own motivation (see p. 300).

Playful behavior is strong evidence against that theory of all behavior which holds that it consists in seeking "equilibrium" or in removing stimulation. On this theory we eat to escape the hunger pangs, as we pull our hand away from a hot stove. The theory can be made to seem reasonable when applied to the reflexes and to many serious affairs of life, but it can scarcely hold good of play. One who goes out to play is seeking activity, and the game is so devised that each response leads not to equilibrium but to a situation calling for further response. A child, or an adult who has no conflicting duties, will play till he is fatigued, when, indeed, the seeking for equilibrium sets in.

DAYDREAMS

(Daydreaming is distinctly a form of play, and the fact that it is so universal an amusement shows that mental activity, as well as motor, is self-motivating. Yet personal motives can often be detected in a daydream) Simply letting the mind run on, as in the instances cited under free association, where A reminds you of B and B of C, and so on — this is not exactly daydreaming, since there is no "dream," no castle in the air nor other construction. (A daydream typically looks toward the future, as if planning for possible action; only, it is not a serious plan — which would be controlled imagination — nor necessarily a plan which could work in real life, but merely play of imagination)

Mastery daydreams. (Daydreams usually have a *hero*, and that hero is usually the dreamer's self. Sometimes one is the conquering hero, and sometimes the suffering hero, but in both cases the recognized or unrecognized merit of oneself is the big fact in the story, so that the mastery motive is evidently finding satisfaction here as well as in other forms of play.) Probably the conquering hero dream is the commoner and healthier variety. A classical example is that of the milkmaid who was carrying on her head a pail of milk she had been given. "I'll sell this milk for so much, and with the money buy a hen. The hen will lay so many eggs, worth so much, for which I will buy me a dress and cap. Then the young men will wish to dance with me, but I shall spurn them all with a toss of the head." Her dream at this point became so absorbing as to get hold of the motor system and call out the actual toss of the head — but we are not after the moral just now; we care simply for the dream as a very true sample of many, many daydreams. Such dreams are a means of getting for the moment the satisfaction of some desire, without the trouble of real execution; and the desire gratified is very often some variety of self-assertion. (Sometimes the hero is not the dreamer's self, but some one closely identified with himself. The mother gratifies her pride in her son by making him her daydream hero)

The "suffering hero" daydream seems at first thought inexplicable, for why should any one picture himself as having a bad time, as misunderstood by his best friends, ill-treated by his family, jilted by his best girl, unsuccessful in his pet schemes? Why should any one make believe to be worse off than he is; what satisfaction can that be to him? Certainly, one would say, the mastery motive could not be active here. And yet — do we not hear children *boasting* of their misfortunes? "Pooh! That's only a little scratch; I've got a real deep cut." My cut being more important than your scratch makes me, for the moment, more important than you, and gives me a chance to boast over you. Older people are known sometimes to magnify their own ailments, with the apparent aim of enhancing their own importance. Perhaps the same sort of motive underlies the suffering hero daydream.

I am smarting, let us suppose, from a slight administered by my friend; my wounded self-assertion demands satisfaction. It was a very little slight, and I should make myself ridiculous if I showed my resentment. But in imagination I magnify the injury done me, and go on to picture a dreadful state of affairs, in which my friend has treated me very badly indeed, and perhaps deserted me. Then I should not be ridiculous, but so deeply wronged as to be an important person, one to be talked about; and thus my demand for importance and recognition is gratified by my daydream.

Usually the suffering hero pictures himself as in the right, and animated by the noblest intentions, though misunderstood, and thus further enhances his self-esteem; but sometimes he takes the other tack and pictures himself as wicked — but as very, very wicked, a veritable desperado. It may be his self-esteem has been wounded by blame for some little meanness or disobedience of his own, and he restores it by imagining himself a great, big, important sinner instead of a small and ridiculous one. In adolescence, the individual's growing demand for independence is often balked by the continued domination of his elders, and he rebelliously plans quite a career of crime for himself. He'll show them! They won't be so pig-headedly complacent when they know they have driven him to the bad. You can tell by the looks of a person whose feelings are hurt that he is imagining something; usually he is imagining himself either a martyr or a desperado, or some other kind of suffering hero. (The suffering hero daydream is a substitute for a fight or some other active self-assertion. The conquering hero daydream is often motivated in the same way; for example, our friend the milkmaid would not have been so ready to scorn the young men with a toss of the head if she had not been feeling her own actual inferiority and lack of fine clothes. The daydream makes good, in one way or another, for actual inability to get what we desire.)

Other motives in daydreams. The desire which is gratified in the play of imagination belongs very often indeed under the general head of self-assertion; but when one is in love it is apt to belong under that head. Love dreams of the agreeable sort need no further motivation; but the unpleasant, jealous type of love dream is at the same time a suffering hero dream, and certainly involves wounded self-assertion along with the sexual impulse. Probably the self-asserting daydream is the commonest variety, take mankind as a whole, with the love dream next in order of frequency. But there are many other sorts. There is the humor daydream, illustrated by the young person who suddenly breaks into a laugh and when you ask why replies that she was thinking how funny it would be if, etc., etc. She is very fond of a good laugh, and not having anything laughable actually at hand proceeds to imagine something. So, a music lover may mentally rehearse a piece when he has no actual music to enjoy; and if he has some power of musical invention, he may amuse himself, in idle moments, by making up music in his head; just as one who has some ability in decorative design may fill his idle moments by concocting new designs on paper. When vacation time approaches, it is hard for any one, student or professor, to keep the thoughts from dwelling on the good times ahead, and getting some advance satisfaction. Thus all kinds of desires are gratified in imagination.

Worry. Do we have fear daydreams, as we have amusements utilizing the fear and escape motive? Yes, sometimes we imaging ourselves in danger and plan out an escape. One individual often amuses himself by imagining he is arrested and accused of some crime, and figuring out how he could establish an alibi or otherwise prove his innocence. But fear daydreams also include *worry*, which seems at first to be an altogether unpleasant state of mind, forced upon us and not indulged in as most daydreams are. Yet, as the worry is often entirely needless, it cannot be forced upon a person, but must have some motive. There must be some satisfaction in it, in spite of all appearance.

Some abnormal cases of worry suggest the theory that the fear is but a cloak for unacknowledged desire. Take this extreme case. A young man, "tied to the apron-strings" of a too affectionate and too domineering mother, has a strong desire to break loose and be an independent unit in the world; but at the same time, being much attached to his mother, he is horrified by this desire. She goes on a railroad journey without him — just an ordinary journey with no special danger — but all the time she is away he is in an agony of suspense lest the train may be wrecked. Such an abnormal degree of worry calls for explanation. Well — did not the worry perhaps conceal a wish, a wish that the train *might* be wrecked? So he would be set free without any painful effort on his part; and he was a young man who shrank from all effort. The psychopathologist who studied the case concluded that this was really the explanation of the worry.

If, however, we take such extreme cases as typical and cynically apply this conception to all worries, we shall make many mistakes. A student worries unnecessarily about an examination; therefore, he desires to fail. A mother worries because her child is late in getting home; therefore, she wants to be rid of that child. Thus, by being too psychopathological, we reach many absurd conclusions in everyday life; for it is the child that is loved that is worried over, and it is the examination that the student specially wishes to pass that he fears he has flunked.

Worry is a substitute for real action when no real action is possible. The student has done all he can do; he has prepared for the examination, and he has taken the examination; now there is nothing to do except wait; so that the rational course would be to dismiss the matter from his mind; if he cannot accomplish that, but must do something, the only thing he can do is to speculate and worry. So also the mother, in her uncertainty regarding her child, is impelled to action, but there the conquering hero dream is the commoner and healthier variety. A classical example is that of the milkmaid who was carrying on her head a pail of milk she had been given. "I'll sell this milk for so much, and with the money buy a hen. The hen will lay so many eggs, worth so much, for which I will buy me a dress and cap. Then the young men will wish to dance with me, but I shall spurn them all with a toss of the head." Her dream at this point became so absorbing as to get hold of the motor system and call out the actual toss of the head — but we are not after the moral just now; we care simply for the dream as a very true sample of many, many daydreams. Such dreams are a means of getting for the moment the satisfaction of some desire, without the trouble of real execution; and the desire gratified is very often some variety of self-assertion. Sometimes the hero is not the dreamer's self, but some one closely identified with himself. The mother gratifies her pride in her son by making him her daydream hero.

The "suffering hero" daydream seems at first thought inexplicable, for why should any one picture himself as having a bad time, as misunderstood by his best friends, ill-treated by his family, jilted by his best girl, unsuccessful in his pet schemes? Why should any one make believe to be worse off than he is; what satisfaction can that be to him? Certainly, one would say, the mastery motive could not be active here. And yet — do we not hear children *boasting* of their misfortunes? "Pooh! That's only a little scratch, I've got a real deep cut." My cut being more important than your scratch makes me, for the moment, more important than you, and gives me a chance to boast over you. Older people are known sometimes to magnify their own ailments, with the apparent aim of enhancing their own importance. Perhaps the same sort of motive underlies the suffering hero daydream.

I am smarting, let us suppose, from a slight administered by my friend; my wounded self-assertion demands satisfaction. It was a very little slight, and I should make myself ridiculous if I showed my resentment. But in imagination I magnify the injury done me, and go on to picture a dreadful state of affairs, in which my friend has treated me very badly indeed, and perhaps deserted me. Then I should not be ridiculous, but so deeply wronged as to be an important person, one to be talked about; and thus my demand for importance and recognition is gratified by my daydream.

Usually the suffering hero pictures himself as in the right, and animated by the noblest intentions, though misunderstood, and thus further enhances his self-esteem; but sometimes he takes the other tack and pictures himself as wicked — but as very, very wicked, a veritable desperado. It may be his self-esteem has been wounded by blame for some little meanness or disobedience of his own, and he restores it by imagining himself a great, big, important sinner instead of a small and ridiculous one. In adolescence, the individual's growing demand for independence is often balked by the continued domination of his elders, and he rebelliously plans quite a career of crime for himself. He'll show them! They won't be so pig-headedly complacent when they know they have driven him to the bad. You can tell by the looks of a person whose feelings are hurt that he is imagining something; usually he is imagining himself either a martyr or a desperado, or some other kind of suffering hero. (The suffering hero daydream is a substitute for a fight or some other active self-assertion. The conquering hero daydream is often motivated in the same way; for example, our friend the milkmaid would not have been so ready to scorn the young men with a toss of the head if she had not been feeling her own actual inferiority and lack of fine clothes. The daydream makes good, in one way or another, for actual inability to get what we desire.)

Other motives in daydreams. The desire which is gratified in the play of imagination belongs very often indeed under the is nothing to do, except in imagination. Worry is fundamentally due to the necessity of doing something with any matter that occupies our mind; it is an imaginative substitute for real action.

But worry may be something of an indoor sport as well. Consider this — if the mother really believed her child had fallen into the pond, she would rush to pull him out. Really she expects to see him come home any minute, but by conjuring up imaginary dangers she is getting ready to make his home-coming a great relief instead of a mere humdrum matter. She is getting the thrill of danger with escape fully expected.

Use and abuse of daydreams. The normal time for a daydream is the time when there is no real act to be performed. A strong man uses it as the amusement of an idle moment and promptly forgets it. But one who is lacking in force, especially the personal force needed in dealing with other people, may take refuge in daydreams as a substitute for real doing. Instead of hustling for the money he needs he may, like Micawber, charm himself with imagining the good opportunities that may turn up. Instead of going and making love to the lady of his choice, he shyly keeps away from her and merely dreams of winning her. He substitutes imaginary situations for the real facts of his life, and gratifies his mastery motive by imaginary exploits. He invents imaginary ailments to excuse his lack of real deeds. He conjures up imaginary dangers to worry over. All this is abuse of imagination.

DREAMS

Let us turn from daydreams to dreams of the night. These also are play of imagination, even freer from control and criticism than the daydream. In sleep the brain activity sinks to a low level, and perhaps ceases altogether in the deepest sleep. Most of the dreams that are coherent enough to be recalled probably occur just after we have gone to sleep or just before we wake up, or at other times when sleep is light. At these times the simpler and more practised functions, such as recall of images, can go on, though criticism, good judgment, reasoning, and all that sort of delicate and complex activity, do not occur. Daytime standards of probability, decorum, beauty, wit, and excellence of any sort are in abeyance; consistency is thrown to the winds, the scenes being shifted in the middle of a speech, and a character who starts in as one person merging presently into somebody else. Dreams follow the definition of imagination or invention, in that materials recalled from different contexts are put together into combinations and rearrangements never before experienced. The combinations are often bizarre and incongruous.

Seeming reality of the dream. Perhaps the most striking characteristic of dreams is their seeming reality while they last. They seem real in spite of their incongruity, because of the absence of critical ability during sleep. In waking life, when the sight of one object reminds me of another and calls up an image of that other, I know that the image is an image, and that I have thought of two different things. In sleep the same recall by association occurs, but the image is forthwith accepted as real; and thus things from different sources get together in the same dream scene, and a character who reminds us of another person forthwith becomes that other person. We are not mentally active enough in sleep to hold our images apart. Associative recall, with blending of the recall material, and with entire absence of criticism, describes the process of dreaming.

The stimulus to which the dream responds. Sometimes there is an actual sensory stimulus, like the alarm clock or a stomach ache; and in this case the dream comes under the definition of an illusion; it is a false perception, more grotesquely false than most illusions of the day. A boy wakes up one June morning from a dream of the Day of Judgment, with the last trumpet pealing forth and blinding radiance all about — only to find, when fully awake, that the sun is shining in his face and the brickyard whistle blowing the hour of four-thirty A.M. This was a false perception. More often, a dream resembles a daydream in being a *train of thoughts and images* without much relation to present sensory stimuli; and then the dream would come under the definition of hallucination instead of illusion.

Sometimes a sensory stimulus breaks in upon a dream that is in progress, and is interpreted in the light of this dream. In one experiment (9) the dreamer, who was an authoress, was in the midst of a dream in which she was discussing vacation plans with a party of friends, when the experimenter disturbed her by declaiming a poem; in her dream this took the form of a messenger from her publisher, reciting something about a contract which seemed a little disturbing but which she hoped (in the dream) would not interfere with her vacation. Maury, an early student of this topic, was awakened from a feverish dream of the French Revolution by something falling on his neck; this, under the circumstances of his dream, he took to be the guillotine.

Motivation of dreams. What satisfaction does a dream bring to the dreamer? Or shall we say that it is merely a mechanical play of association, with no motivation in it? Dreams are interesting while they last, sometimes fearful, sometimes angry, sometimes amorous, otherwise not very emotional but distinctly interesting, so that many people hate to have a dream broken up by awaking. It seems likely, then, that dreams are like daydreams in affording gratification to desires. They are "wish-fulfilling," to borrow a term from Freud's theory of dreams, soon to be considered.

A boy dreams repeatedly of finding whole barrels of assorted jackknives, and is bitterly disappointed every time to awake and find the knives gone. An adult frequently dreams of finding money, first a nickel in the dust, and then a quarter close by, and then more and more, till he wakes up and spoils it all. Such dreams are obviously wish-fulfilling, as are also the sex dreams of sexually abstinent persons, or the feasting dreams of starving persons, or the polar explorer's recurring dream of warm, green fields. An eminent psychologist (2) has given a good account of a dream which he had while riding in an overcrowded compartment of a European train, with the window closed and himself wedged in tightly far from the window. In this uncomfortable situation he dropped asleep and dreamed that he had a seat next to the window, had the window open and was looking out at a beautiful landscape. In all these cases *the wish gratified in the dream is one that has been left unsatisfied in the daytime.* The desires that are satisfied during the day do not demand satisfacton in dreams; but any desire that is aroused during the day without being able to reach its conclusion is likely to come to the surface in a dream.

The mastery motive, so prominent in daydreams, can be detected also in many sleep dreams. The gliding or flying dream, which many people have had, reminds us of the numerous toys and sports in which defiance of gravity is the motive; and certainly it gives you a sense of power and freedom to be able, in a dream, to glide gracefully up a flight of stairs, or step with ease from the street upon the second-story balcony. One dream which at first thought cannot be wish-fulfilling perhaps belongs under the mastery motive: The dreamer sees people scurrying to cover, looks up and sees a thunderstorm impending; immediately he is struck by lightning and knocked down in the street; but he finds he can rise and walk home, and seems to have suffered no harm except for a black blotch around one eye. Now, any man who could take lightning that way would be proud to wear the scar. So the dream was wish-fulfilling, and the wish involved was, as often, the self-assertive impulse.

This last dream is a good one, however, for pointing another moral. We need not suppose that the dreamer was aiming at the dénouement from the beginning of the dream. Dreams have no plot in most instances; they just drift along, as one thing suggests another. The sight of people running to cover suggested a thunderstorm, and that suggested that "I might get struck," as it would in the daytime. Now, the dream mentality, being short on criticism, has no firm hold on "may be" and "might be," but slides directly into the present indicative. The thought of being struck is *being* struck, in a dream. So we need not suppose that the dreamer pictured himself as struck by lightning in order to have the satisfaction of coming off whole and bragging of the exploit. In large measure the course of a dream is determined by free association; but the mastery motive and other easily awakened desires act as a sort of bias, facilitating certain outcomes and inhibiting others.

But there are unpleasant dreams, as well as pleasant. There are fear dreams, as well as wish dreams. A child who is afraid of snakes and constantly on the alert against them when out in the fields during the day, dreams repeatedly of encountering a mass of snakes and is very much frightened in his sleep. Another child dreams of wolves or tigers. A person who has been guilty of an act from which bad consequences are possible, dreams that those consequences are realized. The officer suffering from nervous war strain, or "shell shock," often had nightmares in which he was attacked and worsted by the enemy.

A large share of dreams does not fit easily into any of the classes already described. They seem too fantastic to have any personal meaning. Yet they are interesting to the dreamer, and they would be worth going to see if they could be reproduced and put on the stage. Isn't that sufficient excuse for them? May they not be simply a free play of imagination that gives interesting results just because of its freedom and vividness?

Freud's Theory of Dreams. Just at this point we part company with Freud, whose ideas on dreams as wish-fulfilments we have been following in the main (3). Not that Freud would approve our account of dreams up to this point. Far from it. It would seem to him on too superficial a level altogether, dealing as it does with conscious wishes and with straightforward fulfilments. It has left out of account the "Unconscious" and its symbolisms. The Freudian would shake his head at our interpretation of the lightning dream, and say, "Oh, there is a good deal more in that dream. We should have to analyze that dream, by letting the dreamer ask himself what of real personal significance the stroke of lightning or the scar around the eye suggested to him. He would never be able by his unaided efforts to find the unconscious wishes fulfilled in the dream, but under the guidance of the psychoanalyst, who is a specialist in all matters pertaining to the Unconscious, he may be brought to realize that his dream is the symbolic expression of wishes that are unconscious because they have been repressed."

The Unconscious, according to Freud, consists of forbidden wishes — wishes forbidden by the moral and social standards of the individual. A repressed wish does not peaceably leave the system, but sinks to an unconscious state in which it is still active and liable to make itself felt in ways that are disguised and symbolic. An abnormal worry is such a disguise, a queer idea that haunts the nervous person is another, "hysterical" paralysis or blindness is another (pp. 282, 317).

In normal individuals the dream life is held by Freud to be the chief outlet for the repressed wishes. Even in dreams they dare not show themselves in their true shape and color, but disguise themselves in innocent-appearing symbolism. That lightning may stand for something much more personal. Let your mind play about that "being knocked down by lightning and getting up again," and ask yourself what experience of childhood it calls up. — Well, I remember the last time my father whipped me and I came through defiant, without breaking down as I always had on similar occasions. — Yes, now we are on the track of something. The lightning symbolizes your father and his authority over you, which as a child you resented. You were specially resentful at your father's hold on your mother, whom you regarded as yours, your father being a rival with an unfair advantage. Your sex impulse was directed toward your mother, when you were a mere baby, but you soon came to see that your father stood in the way. You resented this, you hated your father, while you loved him, too; so this whole complex and troublesome business was repressed to the Unconscious, whence it bobs up every night in disguise.

Freud has claimed the dream as his special booty, and insists that all dreams are wish-fulfillments, even those that seem mere fantastic play of imagination, since, as he sees it, no mental activity could occur except to gratify some wish. Further, he holds, most adult dreams are fulfillments of repressed wishes which are either sex or spite wishes, the spite wishes growing out of the interference of other people with our sex wishes.

While the psychoanalytic school of Freud regards the dream of an adult as an embodiment of some experience of childhood and a disguised fulfillment of the child's desire, the related schools of Adler (1) and of Jung (4) take a different view. According to Adler the dream is not a revival of the distant past but a rehearsal for some impending action which the individual has to perform, and the dream, properly analyzed, reveals the individual's characteristic mode of attack on his problems. For Jung, the dream is related to the individual's present difficulties and reveals his unconscious attitude towards his life problems.

Objections to Freud's theory. The objection of Jung and of Adler, that the dream is an expression of the individual as he is rather than of the individual as he once was, seems well taken.

An objection to all these theories is that they fail to take account of the easy-running recall mechanism. We need not look for big, mysterious driving forces, when we know that A makes you think of B, and B of C, with the greatest ease. The dreamer isn't laboring, he is idly playing, and his images come largely by free association, with personal desires giving some steer.

Another objection is that Freud overdoes the Unconscious; unfulfilled wishes are usually not so unconscious as he describes them; they are unavowed, unnamed, unanalyzed, but conscious for all that. It is not so much the unconscious wish that finds outlet in dreams and daydreams, as the unsatisfied wish, which may be perfectly conscious.

Another objection is that he overdoes the sex motive or "libido." His analysis of human motives is incomplete. He does not clearly recognize the self-assertive tendency, which, as a matter of fact, is subjected to much suppression from early childhood all through life, and which undoubtedly has much to do with dreams, as it has with daydreams. Freud has given an "impressionistic" picture, very stimulating and provocative of further exploration, but by no means to be accepted as a true and complete map of the region.

AUTISTIC THINKING

Dreaming, whether awake or asleep, is free imagination. It does not have to check with any standard. So long as it is interesting and gratifies the dreamer, it serves its purpose. Sometimes the daydreamer exercises some control, breaking off a spiteful or amorous dream because he thinks it had better not be indulged; but in this he ceases to be simply a daydreamer. Daydreaming, by itself, is an example of what is called "autistic thinking," which means thinking that is sufficient unto itself, and not subjected to any criticism. Autistic thinking gratifies some desire and that is enough for it. It does not submit to criticism from other persons nor from the individual himself, nor does it seek to square itself with the real world.

Autistic thinking, indulged in by every imaginative person in moments of relaxation, is carried to an absurd extreme by some types of insane individuals. One type withdraws so completely from reality as to be inaccessible in conversation, unresponsive to anything that happens, entirely immersed in inner imaginings. Others, while living in the world about them, transform it into a make-believe world by attaching meanings to things and persons as suits themselves. This institution, in which the subject is confined, is his royal palace, the doctors are his officials, the nurses his wives, " thousands of them, the most beautiful women in creation." Or the delusion may take the line of the suffering hero, the subject imagining himself a great man shut up in this place by the machinations of his enemies; the doctors are spies and enemy agents, and the nurses also act suspiciously; his food is poisoned, and he is kept in a weak and helpless condition, all out of fear of him. It is impossible to argue the patient out of his delusions by pointing out to him how clearly they conflict with reality; he evades the evidence by some counter-argument, no matter how flimsy, and sticks to his dream or make-believe.

Autistic thinking is contrasted with realistic thinking, which seeks to check with real facts; it may be contrasted also with socialized thinking, which submits to the criticism of other people; and it may even be contrasted with self-criticized thinking, in which the individual scrutinizes what he has imagined, to see whether it is on the whole satisfactory to himself, or whether it simply gratified a momentary impulse running counter to more permanent desires.

INVENTION AND CRITICISM

"Criticism" — the word has been used repeatedly, and it is time it gave an account of itself. One desire gets criticized by running afoul of another desire, one idea by conflicting with another idea. We concoct a fine joke to play on our friend; but then the thought comes to us that he may not take it kindly; we don't want to break with our friend, and so we regretfully throw our promising invention on the scrap heap. That is self-criticism, the balancing off of one impulse by another. Self-criticism is obnoxious to the natural man, who prefers to follow out each desire till it reaches its goal; but he learns self-criticism in the hard school of experience. For plenty of criticism is directed upon the individual from without.

Criticism is directed upon him by the facts of the real world, so soon as he tries to act out what he has imagined. Often his invention will not work, his plan does not succeed, and he must cast it away and think up a new one. At this point the "weak brother" is tempted to give up trying, and take refuge in autistic thinking, but the stronger individual accepts the challenge of reality. He sees that an invention is not satisfactory unless it will work, and sets about learning what will work and what will not, so accumulating observations that later enable him to criticise his own ideas, to some extent, before trying them out on real things.

Criticism is directed upon the individual from the side of other people, who, from the day he first begins to tell his childish imaginings, are quite free with their objections. Humiliated by this critical reception of his ideas, the individual may resolve to keep them to himself for the future, and may take refuge in autistic thinking; or, more forcefully, he exerts himself to find some idea that will command the approval of other people. If he can take rebuffs goodnaturedly, he soon finds social criticism a great help, and two heads better than one in planning any invention. He accumulates knowledge of what will pass muster when presented to other people, and thus again learns self-criticism.

Self-criticism is helped by such rules as to "think twice," to "sleep on it before deciding," to "drop the matter for a time and come back to it and see whether it still looks the same." When you are all warmed up over an idea, its recency value gives it such an advantage over opposing ideas that they have no chance, for the moment, of making themselves felt in the line of criticism.

I once heard the great psychologist, and great writer, William James, make a remark that threw some light on his mode of writing. In the evening, he said, after warming up to his subject, he would write on and on till he had exhausted the lead he was following, and lay the paper aside with the feeling, "Good! Good! That's good." The next morning, he added, it might not seem good at all. This calls to mind the old advice to writers about its being "better to compose with fury and correct with phlegm than to compose with phlegm and correct with fury." The phlegmatic critical attitude interferes considerably with the enthusiastic inventive activity. Give invention free rein for the time being, and come around with criticism later.

Some over-cautious and too self-critical persons, though rather fertile in ideas, never accomplish much in the way of invention because they cannot let themselves go. Criticism is always at their elbow suggesting doubts and alternatives and preventing progress in the creative activity, instead of biding its time and coming in to inspect the completed result. For a similar reason, much of the best inventive work — writing, for example, or painting — is done in prolonged periods of intense activity, which allow time for invention to get warmed to its task, when it takes the bit in its teeth and dashes off at a furious speed, leaving criticism to trail along behind.

Invention in the service of art or of economic and social needs is controlled imagination, realistic, socialized, subjected to criticism. It cannot afford to be autistic, but must meet objective or social standards. Mechanical inventions must work when translated into matter-of-fact wood and iron, and must also pass the social test of utility. Social inventions of the order of institutions, laws, political platforms and slogans, plans of campaign, must work in the sense of bringing the desired response from the public. Social imagination of the very important sort suggested by the proverbs, "Seeing ourselves as others see us," or "Putting ourselves in the other fellow's place" — for it is only by imagination that we can thus get outside of our own experience and assume another point of view — must square with the real sentiments of other people.

THE ENJOYMENT OF IMAGINATIVE ART

It requires imagination to enjoy art as well as to produce it. The novelist describes a character and you, the reader, respond by putting together the items in the description so as to conceive of a character you have never met. The painter groups his figures before you, but you must get the point of the picture for yourself. The musical composer provides a series of chords, but you must get the pattern of the passage for yourself, and if he has introduced a novel effect, it may not be easy to find any beauty in it on the first hearing.

Art, from the consumer's side, is play. It is play of the imagination, with the materials conveniently presented by the artist. Now, as art is intended to appeal to a consumer (or enjoyer), the question as to sources of satisfaction in the enjoyment of art is fundamental in the whole psychology of art, production as well as consumption.

Motivation of novel-reading. We have the same questions to ask regarding the enjoyment of a *novel* as regarding a daydream. Novel-reading is daydreaming with the materials provided by the author, and gratifies the same motives. A novel to be really popular must have a genuine hero or heroine — someone with whom the reader can identify himself. The frequency of novels in which the hero or heroine is a person of high rank, or wins rank or wealth in the course of the story, is a sign of appeal to the mastery motive. The humble reader is tickled in his own self-esteem by identifying himself with the highborn or noble or beautiful character in the story. The escape motive also is relied upon to furnish the excitement of the story, which always brings the hero into danger or difficulty and finally rescues him, much to the reader's relief. Love stories appeal, of course, to the sex impulse, humorous stories to laughter, and mystery stories to curiosity. Cynical stories, showing the "pillars of society" in an ignoble light, appeal to the self-assertive impulse of the reader, in that he is led to apply their teaching to pretentious people whom he knows about, and set them down a peg, to his own relative advancement. But here again we have to insist, as under the head of sports and daydreams, that interests of a more objective kind also are gratified by a good work of fiction. A story that runs its logical course to a tragic end is interesting as a good piece of workmanship, and as an insight into the world. We cannot heartily identify ourselves with Hamlet or Othello, yet we should be sorry to have those figures erased from our memories; they mean something, they epitomize world facts that compel our attention.

The appeal of art is partly emotional. A great work of art, the Apollo Belvedere or the Sistine Madonna, when you suddenly come upon it in walking through a gallery, may move you almost to tears. Beautiful music, and not necessarily sad music either, has the same effect. Why this particular emotion should be aroused is certainly an enigma. "Crying because you are so happy" is similar but itself rather inexplicable. In many other cases, the emotional appeal of art is easily analyzed.

Art makes also an intellectual appeal. Many great works of art require mental effort in order to appreciate them. You must be wide-awake to follow a play of Shakespeare; you must puzzle out the meaning of a group painting before fully enjoying it; and music may be too "classical" for many to grasp and follow. Unless, then, the artist has made a great mistake, the mental activity which he demands from his public must contribute to the satisfaction they derive from his works. If his appeal were simply to their emotions, any intellectual labor would be a disturbing element. The intellectual appeal is partly to objective interests in the thing presented, partly to interest in the workmanship and partly to the mastery motive in the form of problem solution.

Perhaps we do not often think of a fine painting or piece of music as a problem set us for solution, but it is that, and owes part of its appeal to its being a problem. If the problem presented is too difficult for us, the work of art is dry; if too easy, it is tame.

The mastery motive may be as important in the enjoyment of art as it seemed to be in play and in dreaming. It comes in twice: once in the joy of solving the problems presented by the work of art, and again in identification with the fine characters portrayed.

Empathy in art enjoyment. At first thought, some forms of art seem incapable of making the just mentioned double appeal to the mastery motive. Architecture can certainly present problems for the beholder to solve, but how can the beholder possibly identify himself with a tower or arch? If, however, we remember the "empathy" that we spoke of under the head of play, we see that the beholder may project himself into the object, unintentionally of course, and thus perhaps get satisfaction of his mastery impulse.

Look at a pillar, for example. If the pillar is too massive for the load supported, it gives you the unsatisfactory impression of doing something absurdly small. If it is too slender for the load that seems to rest upon it, you get the feeling of strain and insecurity; but if it is rightly proportioned, you get the feeling of a worthy task successfully accomplished. The pillar, according to empathy, pleases you by arousing and gratifying your mastery impulse; and many other architectural effects can be interpreted in the same way.

Empathy can perhaps explain the appeal of the *big* in art and nature. In spite of the warnings put forth against thinking of mere bigness as great or fine, we must admit that size makes a very strong appeal to something in human nature. Big trees, lofty cliffs, grand canyons, tremendous waterfalls, huge banks of clouds, the illimitable expanse of the sea, demonstrate cogently the strong appeal of the big. Perhaps the big is not necessarily grand, but the grand or sublime must be big or somehow suggest bigness. The question is, then, what it is in us that responds to the appeal of the big.

Perhaps a submissive attitude is aroused. This great mountain, so far outclassing me, affords me the joy of willing submission. The escape motive may come in along with submissiveness — at the first sight of the mountain a thrill of fear passes over me, but I soon realize that the mountain will not hurt me in spite of its awe-inspiring vastness; so that my emotion is blended of the thrill of fear, the relief of escape and the humble joy of submission. That is one analysis of the esthetic effect of bigness.

Empathy suggests a very different analysis. According to this, projecting myself into the mountain, identifying myself with it, I experience the sensation of how it feels to be a mountain. It feels big — I feel big. My mastery impulse is gratified. To decide between these two opposing interpretations ought to be possible from the behavior or introspection of a person in the presence of some big object. If he feels insignificant and humble and bows reverently before the object, we may conclude that a submissive attitude is aroused; but if the sight of the grand object makes him feel strong and fine, if he throws out his chest and a gleam comes into his eye, then everything looks like the mastery motive. Quite possibly, the effect varies with the person and the occasion.

We have to think of art as a great system or collection of inventions that owes its existence to its appeal to human nature, and that has found ways, as its history has progressed, of making its appeal more and more varied. Art is a type in these respects of many social enterprises, such as sport, amusement, and even politics and industry. Each of these is a collection of inventions that persists because it appeals to a variety of human impulses.

THE PSYCHOLOGY OF INVENTIVE PRODUCTION

To the consumer, art is play, but to the producer it is work, in the sense that it is directed toward definite ends and has to stand criticism. What is true of the producer of art works is true also of other inventors, and we may as well consider all sorts of controlled imagination together.

In spite of the element of control that is present in productive invention, the really gifted inventor makes play of his work. He does not always have his eyes fixed on the financial goal, nor on the appeal which his inventions are to make to the public. It is astonishing to read in the lives of inventors (10) what a lot of comparatively useless contrivances they busied themselves with, apparently from the pure joy of inventing. One prolific writer said that he " never worked in his life, only played." The inventor likes to manipulate his materials, and this playfulness has something to do with his originality, by helping to keep him out of the rut.

That "necessity is the mother of invention" is only half of the truth: it points to the importance of a directive tendency, but fails to show how the inventor manages to leave the beaten path and really invent. Necessity, or some desire, puts a question, without which the inventor would not be likely to find the answer; but he needs a kind of flexibility or playfulness, just because his job is that of seeing things in a new light. We must allow him to toy with his materials a bit, and even to be a bit "temperamental," and not expect him to grind out works of art or other inventions as columns of figures are added.

When inventive geniuses have been requested to indicate their method, they have been able to give only vague hints. How does the musical composer, for example, free himself of all the familiar pieces and bring the notes into a fresh arrangement? All that he can tell about it is usually that he had an "inspiration"; the new air simply came to him. Now, of course the air did not really come to him from outside; he made it, it was his reaction, but it was a quick, free reaction, of which he could observe little introspectively.

Framework and filling. Imagination is sometimes said to consist in putting together materials from different sources, but this synthetic process though certainly present is only half of the story. Thinking of a man and also of a horse is not imagining a centaur; there is a long jump from the mere juxtaposition of the materials to the meaningful whole. Typically the meaningful whole is present, in an embryonic state, before all of the materials are assembled, and the materials are sought because they are needed for filling out the existing whole. A framework is invented and data are assembled to fit into the framework. The plot of the story is outlined before the various incidents are worked out.

We must not make this scheme of the inventive process too hard and fast. The framework itself may grow and be modified by the parts that are fitted into it. Two stories may have the same plot in bare outline but differ considerably because of the differing incidents and characters that are woven in. "Fitting parts into a pre-existing framework," then, is not quite so adequate a formula for the inventive process as the phrase which we used before to describe the development of the organism (see p. 162): "the interaction of parts within a pre-existing whole." In invention, however, the parts are certainly assembled and grafted on to the pre-existing whole, rather than differentiated within the pre-existing whole.

The framework of an invention is akin to the hypothesis which serves the scientific investigator in his search for significant facts, and the inventor as well as the scientist may need to try several "hunches" before he finds one that will work.

Stages in creative thought. In the absence of any exact knowledge of the process by which great discoveries and inventions are achieved, there is considerable interest in a suggestion made by several writers who have given much thought to the matter (7, 11). They divide the whole process into four stages, as follows:

1. Preparation. The problem is examined on all sides, and material is brought together, but a synthesis cannot be achieved.
2. Incubation. No attention is given to the problem during this interval.
3. Illumination — a flash, a "click," an "Aha! experience."
4. Verification or elaboration.

According to the testimony of many inventors (8), the stage of preparation may be long drawn out and include several steps. First, a need or problem is observed and analyzed, then all available information is assembled from memory and from reading, and attempts at a solution are made, criticized and rejected. All this labor, though necessary, is only preliminary to the birth of the new idea which comes without warning on awaking from a good sleep, or while daydreaming, attending a concert or taking a bath — in circumstances that vary from one inventor to another, but not, as they agree, during the anxious search for the new idea.

What can be taking place during the incubation period? No work is consciously being done on the problem, and yet after this interval the solution occurs in a flash. It has been inferred that unconscious work has been going on; but this conclusion is far from sure, for the same possibility is present here as in the case of the forgotten name (see p. 283). In the preparatory period the necessary cues have been assembled along with much irrelevant material which is an interference as long as it possesses "recency value." When this recency value has evaporated with the lapse of time, and when the individual makes a fresh attack, the whole matter is clear. This theory is at least as probable as the theory of subconscious work.

The process by which Coleridge created the *Ancient Mariner* has been made the subject of intensive research (5), and something resembling these four stages can be recognized. An omnivorous reader with a retentive memory, Coleridge had taken special interest in narratives of sea voyages. His plans at the time contemplated much more ambitious poetical works than the *Mariner* or than anything he ever produced. But while awaiting the development of these plans, he took a hiking tour with Wordsworth and the two between them hit upon the simple framework of the *Mariner* story, which Coleridge then filled in, drawing upon his previous accumulation of sea images. The subconscious incubation process, if it occurred, had hooked together these images and raised them to the high degree of vividness which they have in the poem. Or, this work of combination and vivification was part of the elaboration stage.

The social factor in invention. To what extent does the process of invention occur within the individual inventor, and to what extent is it a social process in which the inventor participates? Under present-day conditions of industry, inventors are often brought together in large research organizations and produce by teamwork. So much is demanded in the way of scientific background no less than of material resources that the lone worker is at a disadvantage, though many inventive individuals are lone workers by preference. But even the lone worker does not work entirely alone. He has his books and journals in which the work of his predecessors and contemporaries is brought before him. The problems which he would like to solve have grown out of preceding work and out of the needs of the social group. The rewards of fame and fortune which may spur him on are social rewards. In his lonely workshop or studio he is really participating in group activity. Given a common background and the same problems pressing for solution it is not strange that two or more individuals should arrive at the same invention or discovery independently and almost simultaneously, as has happened again and again in a large way, and as happens all the time in a smaller way. Photography was invented twice in 1839, the telegraph three times in 1837, the telephone twice in 1876, the phonograph twice in 1877. Such coincidences could not recur so often if the social factor in invention were not important (6). If the social factor were everything, however, coincident inventions would be the rule. All investigators working on the same problem at the same time would be bound to produce the same result. Clearly the part of the whole inventive process that occurs within the individual is essential. Clearly, too, there are large individual differences in ability to appropriate the available data, to create the ideal framework and to fit the selected data into the framework.

Schools of art. The history of any art reveals very clearly the social factor in creative work. Creative artists are very commonly found in schools or movements. Each school has a fundamental idea which it exploits, and the members of the school are characterized by loyalty to that idea. In the early days of Wagnerian opera one scarcely thought it decent to enjoy both Wagner and the Italians. It was like trying to be a revolutionary and a conservative alike. With the passage of time this antagonism has died down and both forms of opera can be enjoyed by the same music-lovers and considered worthy forms of art. This calming of the waters has been due largely no doubt to the fact that Wagner has had no great successors to develop his idea and carry it further. If loyalty, *esprit de corps* and similar social factors were the whole story of productive schools, each artist would be content to go on imitating the master, instead of striving each to make his own originality count. Each strives, within the general framework of the school idea, to produce something new. The result is, either to push the idea to an extreme, or to work it out into ever more complicated forms. In either case the school reaches its limit and gives way to some new school with a new framework to be filled out and elaborated. Thus the Gothic architecture, after developing through a period of several hundred years from simple to more and more elaborate forms, gave way suddenly to the Renaissance style; and thus polyphonic music after reaching its climax in Bach gave way to the symphonic music which is still dominant.

Schools of psychology. The case is about the same with the schools which are prominent today in our science, except that they are new schools which have yet, no doubt, to reach their zenith. The psychoanalytic school, of which mention has been made, is concerned primarily with the individual's difficulties of adjustment to life, and is exploiting the idea of repressed wishes and conflict of motives. Behaviorism as a school is exploiting the idea of objective data. It limits its observations to the visible actions of the individual in the environment and hopes thus to bring psychology more closely into line with biology, chemistry and physics. It accordingly declines to take the individual's self-observation or his feelings and experiences as furnishing anything deserving of scientific study. The school of Gestalt psychology or configurationism is exploiting an idea which may be conveyed by the word *pattern,* a word which has been much used in our discussions. This school holds that the individual's process of learning, of perceiving, of thinking, of acting, is always a working from the whole to the parts and not a building of parts together to make a whole. All of these ideas are showing themselves fruitful and deserving of exploitation. Other guiding ideas have also proved fruitful and doubtless there are yet others to emerge (12).

A review of the present book would show considerable use made of results which have, or perfectly well might have, issued from one or another of these schools. The ideal of the book, indeed, might be described as panscholastic. If it contains any distinctive ideas of its own, they probably are: the idea of the synthesis and interaction of parts within a pre-existing whole, and the idea that the fundamental trend of the individual is towards meeting his own needs by participation in the activities of the environment.

REFERENCES

1. Adler, A. *The practice and theory of individual psychology.* 1924.

2. Claparède, R. "Rêve satisfaisant un désir organique." *Arch. de Psychol.,* 1916–17, 16, 300–302.

3. Freud, S. *The interpretation of dreams.* rev. ed. 1933.

4. Jung, C. G. *Collected papers on analytical psychology.* 2d ed. 1920.

5. Lowes, J. L. *The road to Xanadu.* 1927.

6. Ogburn, W. F. *Social change.* 1922.

7. Poincaré, H. *Science and method.* 1914.

8. Rossman, J. *The psychology of the inventor.* 1931.
9. Stepanow, G. "Sogni indotti." *Psiche,* 1915, 4, 1–59.
10. Taussig, F. W. *Inventors and money makers.* 1915.
11. Wallas, G. *The art of thought.* 1926.
12. Woodworth, R. S. *Contemporary schools of psychology.* 1932.
13. Downey, J. E. *Creative imagination.* 1929. This book considers especially the psychology of literature.

QUESTIONS

QUESTIONS ON THE TEXT

These questions and exercises are designed to assist the student in understanding the more difficult passages in the text, and in bringing together material from different parts of a chapter and from different chapters. One good general exercise consists in preparing an outline of each chapter.

CHAPTER I. The Aim of Psychology

1. How can the individual be both dependent on the environment and relatively separate from the environment?

2. Show the sequence of processes that occurs around and within an individual when the blowing of a whistle causes him to stop his car.

3. Why is a kick delivered to a dog a stimulus but one delivered to a football not a stimulus?

4. What truth is conveyed by the simple S-R formula, what is added by introducing O into the formula, and what further is added by introducing W?

5. What is added by attaching little w to O in the formula?

6. Explain the meaning of "orientation," with two examples.

7. Show by aid of two examples that "activity in progress" must be known before we can predict O's response to a certain stimulus.

8. Which of the "fundamental principles" would still hold good if "social group" (e.g., a football team or a business firm) were substituted for "individual"?

CHAPTER II. The Methods of Psychology

1. Why is anyone more likely to resort to the anecdotal method in a psychological discussion than in discussing a problem in physics, chemistry or biology?

2. Take the hypothesis, "A lesson will be better retained if the study of it is immediately followed by a rest period," and plan an

experiment to test this hypothesis. What factors would you hold constant, and what would be your independent and dependent variables?

3. Why does psychology ever resort to any other than the experimental method?

4. What data should be included in a complete case history?

5. Show, in the case of speech, the difference between a behavior study and a physiological study.

6. Compare the time it takes you to add 20 one-place numbers, arranged in a vertical column, and 20 arranged in a horizontal line. Note which arrangement was more agreeable. Now show which of your data are introspective and which are behavior data.

CHAPTER III. Individual Differences

1. Survey of one's own imagery. Try to call up the images prescribed below, and rate each image as follows:

3. . . . image clear, bright, realistic
2. . . . image only moderately bright and realistic
1. . . . image almost devoid of sensory quality
0. . . . no sensory image even when the object is remembered

Call up the visual appearance of: a sunflower, automobile head lights, large dog, your own signature

Call up the sound of: church bell, dog barking, siren whistle, paper tearing

Call up the feel of: velvet, a lump of ice, lifting a heavy weight, riding in an automobile

Call up the odor of: coffee, camphor, apple, onion

Compare your average rating for each of the four classes.

2. Represent by diagrams two distributions having the same average but different amounts of scatter; also two distributions having the same scatter but different averages.

3. Draw a distinctly bimodal distribution diagram.

4. Read off from Figures 7 and 8 the approximate mode for right hand grip, left hand grip, right hand accuracy score, right hand tapping.

5. Why do two equivalent tests, tried on the same group of people, never give absolutely perfect correlation?

6. What size correlations would you class as high, as moderate, as low?

CHAPTER IV. INTELLIGENCE

1. How can an intelligence test be checked for reliability, and for validity?

2. If a child of six has an M.A. of 7 years 6 months, what will be his M.A. at the age of ten, on the assumption that his IQ remains perfectly constant?

3. In what ways does the Binet test differ from any collection of little problems which one might think up?

4. In attempting to trace the curve of mental growth, what advantage has the method of retesting the same individuals over the method of testing a different group for each age level?

5. Why is it specially difficult to measure the intelligence of adults?

6. Of what value are intelligence tests in ameliorating the condition of the feebleminded?

7. What are the objections to speaking of a "criminal type" of individual?

8. What is the objection to translating IQ into a scale of descriptive terms, such as feebleminded (under 70), dull, average, superior, genius (over 140)?

9. What does the experimental method show regarding the nature of intelligence?

10. What does the correlation method show regarding the nature of intelligence?

CHAPTER V. PERSONALITY

1. Which of the psychological methods described in Chapters II and III seem to be most used in the study of personality?

2. Why is it more difficult to test personality than intelligence?

3. Show how to measure the reliability of a rating scale, and show that its validity could not easily be determined.

4. How should we go about to discover the meaning of introversion and extroversion, following the principles laid down (p. 80) for defining intelligence?

5. Give two reasons why the more intelligent individual might be expected to be more honest than the less intelligent.

6. To judge from the correlations, how does the individual's consistency in point of honesty compare with his consistency in motor tests (see Chapter III)?

7. How is the individual of multiple personality any more inconsistent than the average person?

8. What personal traits seem to change from childhood to adulthood, and what traits seem to remain steady?

CHAPTER VI. FACTORS IN PERSONALITY

1. Which hormones are most important for (a) intellectual activity, (b) motor activity, (c) sex activity, (d) growth?

2. Trace the steps of cause and effect from deficient iodin in the environment to mental sluggishness.

3. Show how each of the effects of adrenin might be of service in an emergency.

4. What is the objection to speaking of the "thyroid personality," the "pituitary personality," etc.?

5. Can the child's personality difficulties be wholly laid to parental mismanagement? Explain.

6. Point out some ways in which the individual creates or selects his own social environment.

7. Point out ways in which the individual resists the influences of his social environment.

8. What social factors were probably important in forming Mark Twain's personality?

CHAPTER VII. HEREDITY AND ENVIRONMENT

1. Comment on this proposition, "The newborn baby is the product mostly of heredity, but in growing up he becomes more and more the product of environment."

2. On the average, how many of an individual's chromosomes are inherited from each of his grandparents, great-grandparents, etc.?

3. Among the studies dealing with the influence on heredity and environment on intelligence, which follow the logic of the "hybrid experiment" and which that of the "monster experiment"?

4. What reasons are there for thinking that home environment is more nearly the same for twins than for other siblings?

5. What difference in growth of intelligence can be due to the earlier maturity of women? Illustrate by drawing the probable growth curve for each sex.

6. How can environmental factors make like individuals unlike and unlike individuals more alike?

7. In what ways is it biologically economical for primitive man to be the hunter while woman is the gardener?

8. Show by rough distribution curves the sex difference in muscular strength or in linguistic ability.

CHAPTER VIII. THE DEVELOPMENT OF THE INDIVIDUAL

1. What can be learned from the development of the eye regarding the process of maturation?

2. What changes occur in a muscle as an after-effect of its activity?

3. What is meant by "atrophy through disuse"?

4. What activities occur before birth, and what difference does birth make in the organism's activity?

5. How can "growth through exercise" be illustrated by the recovery of muscular strength after prolonged illness?

6. What part is played by maturation in the child's acquisition of speech?

7. State two ways in which identical twins can be used in scientific investigation.

8. Outline the experiment on the development of swimming in tadpoles under the following heads which are standard in laboratory reports:

a) the hypothesis to be tested
b) subjects used
c) apparatus and materials used
d) procedure
e) results
f) conclusions

CHAPTER IX. NERVOUS SYSTEM

1. Mention the characteristics of nerves and neurons which fit them for the part they play in the life of the organism.

2. What does the word "sensitivity" mean when applied to a nerve fiber?

3. According to the all or none law, how does a strong muscular contraction differ from one that is weak?

4. Where are the dendrites of the following neurons?

a) Those whose axons make up the optic nerve
b) Those whose axons arouse the leg muscles

c) Those whose axons arouse the eye muscles

d) Those whose axons make up the pyramidal tract

5. Illustrate by a diagram a multiple synapse with converging nerve paths.

6. Summarize all the methods of studying brain functions.

7. What functions are dependent on particular regions of the cortex, and what functions are not thus dependent?

8. How does the modern doctrine of localized brain functions differ from phrenology?

9. What form of blindness results from destruction of each of the following?

a) The left optic nerve

b) The upper front portion of the area striata in the left occipital lobe

c) The occipital lobe outside the area striata

10. What part is played in bodily movement by each of the following?

a) The motor area

b) The premotor area

c) The cerebellum

d) The spinal cord

CHAPTER X. LEARNING

1. What scores besides time could be used in tracing the rat's progress in learning a maze?

2. Show that avoiding the place where a shock has been received means an adjustment to the locality as a whole.

3. In what respects is human maze learning like that of the rat, and in what respects different?

4. "Insight": its minimum definition, its signs or symptoms, and its value in learning.

5. Give illustrations of "higher units" in dancing, piano playing, or any sport.

6. From the data on page 251, plot the curve of extinction of a conditioned reflex and compare it with other learning curves.

7. Can you formulate one general statement covering all the effects of a distracting stimulus in conditioned reflex experiments?

8. Collect the instances in this chapter of repetition as a factor in learning.

9. Collect the instances of reward and punishment as factors in learning.

10. Applying Lloyd Morgan's canon to the delayed reaction experiment, what psychological activities should not be assumed to be necessary in the successful animal?

CHAPTER XI. MEMORY

1. Harmonize the scheme of a memory experiment given on page 262 with the "logical framework of a learning experiment" given on page 224. Illustrate by a particular experiment.

2. Show how reward and punishment come into play in memorizing a list of numbers or nonsense syllables.

3. Show that maze learning uses the recitation method.

4. What rules for efficient study are suggested by the experiments on memory? How can the individual test out these rules for his own use?

5. Mention three causes of imperfect recall of an incident.

6. See whether you have any fixed images or "forms" representing the hours of the day, the months and seasons of the year, past and future time, etc.

7. Under what conditions is the testimony of an eyewitness likely to be erroneous?

8. Show how the principle of reduced cues applies to:
    a) the delayed reaction
    b) conditioned fears
    c) word units in typewriting

9. Show that "memory systems" assume more "transfer" than can reasonably be expected.

10. What qualifications are necessary to the conclusion that quick learning gives slow forgetting?

CHAPTER XII. MOTIVATION

1. Classify fears as primitive, conditioned, etc.

2. How does each of the following occupations afford scope for self-assertion? Medicine, Aviation, Acting, Farming.

3. Are there any activities which do not play the role of motives?

4. Mention two activities which are definitely purposive, and two which are not entitled to be so called.

5. Compare the process of deliberation with the process of learning a maze.

6. Prepare a list of five questions to be included in a "tally questionnaire" (p. 94) for measuring individual differences in decisiveness or force of decision.

7. In what sense can we speak of a desire as unconscious?

8. Give two instances of "prepared action," in which the preparation makes for speed or accuracy.

9. Compare the results of the two experiments cited under the head of "effort."

10. Translate the requirements for army morale into civilian terms.

CHAPTER XIII. Feeling and Emotion

1. Following Wundt's three-dimensional scheme of feeling, analyze each of the following states of mind:

   a) Watching a rocket go up and waiting for it to burst
   b) Just after the rocket has burst
   c) Waiting for the dentist to pull
   d) Just after he has pulled
   e) Enjoying a warm bed.

2. What kinds of sensation (visual, auditory, etc.) contribute most to the background of feeling?

3. How can you define a) one emotion in distinction from another; b) emotional in distinction from unemotional states?

4. How are the facial and vocal expressions of emotion useful in human society?

5. Which part of the face, the eye region or the mouth region, is more expressive of a variety of emotions? Experiment by covering the upper or lower parts of pictures or faces.

6. Draw a breathing curve showing inspiration as a rise and expiration as a descent and compute the I/E ratio for your curve. Draw another curve showing the inspiration and expiration in speaking and compute the ratio for this case also.

7. What centers of the nervous system are connected with the internal organs of the trunk?

8. What effects of adrenin are the same as those of the sympathetic nerves?

9. What are the following feelings according to the James-Lange theory: amusement, sorrow, surprise?

CHAPTER XIV. THE SENSE OF SIGHT

1. What contributions do the rods make to the sense of sight?

2. What is the difference between stimulus white and object white? Between stimulus red and object red?

3. Object black, stimulus black, sensation black — which of them can be called a mere absence of light?

4. To what is the color circle reduced in red-green blindness?

5. If a colored light is projected on a screen and a white light is then superimposed, describe the change in terms of color-tone, etc.

6. Show that the eye is far from a perfect indicator of the wave length of light.

7. Draw a color circle, indicating the complementary color for each of the following: crimson, orange, peacock, lilac.

8. Do you find it easy to observe negative after-images? Can you utilize them for determining the complementary of any given color? How?

9. What eye movements are necessary for clear vision of the landscape seen from a moving vehicle? Try your hypothesis out by watching the eyes of one who is thus looking at the landscape.

10. Explain whether hemianopsia (p. 204) destroys binocular vision.

11. Compare the stimuli received from a point of light moving in a circle and from a motion picture of the same. Assume the eye to remain still.

CHAPTER XV. THE OTHER SENSES

1. What objective facts are revealed by more than one of the senses?

2. Mention two experiments in this chapter which belong under the head of sensation, and two belonging under the head of perception.

3. List the important "accessory apparatus" of the senses of hearing, smell and taste.

4. List the sensitive cells of the several senses, with the precise stimulus of each.

5. What seems to you the most curious fact regarding each of the following senses: touch, temperature, taste, smell?

6. Would you expect the reaction time to taste stimuli to be long or short? Explain.

7. Construct a table comparing the senses of sight and hearing,

showing the variation in sensation corresponding to wave length, intensity and mixture of stimuli.

8. Compare the eye and the ear as registering instruments for physical vibrations, and also as registering instruments for the positions and characteristics of objects.

9. In speaking or singing, how are loud and soft tones produced, high and low tones, and vowel differences?

10. What dimension of space, relative to the body, is revealed by binocular vision? By binaural hearing?

CHAPTER XVI. OBSERVATION

1. Compare the field of consciousness with the field of vision.

2. Give one illustration each from the senses of sight, smell and touch of a weak stimulus of which one is highly conscious.

3. Construct other figures than those in the text to bring out factors of advantage in grouping. Try the effect of using two or more colors.

4. In looking at the shifting figures, what changes do you observe? Would you class them as changes in sensation or in perception?

5. Compare the "coupling of a distraction to the main task" with the "harnessing together of motives" (p. 318).

6. How can the variable error be measured? See Chapter III.

7. Give two further illustrations of the approximate truth of Weber's law in everyday observation.

8. Cite an illusion from everyday life belonging under class 1, and one belonging under class 2.

9. What rules can you formulate to assist in accurate observation?

10. Show that some perceptions amount to conditioned responses.

11. How do the proportions of book covers, etc., compare with the golden section?

CHAPTER XVII. THINKING

1. Record a short revery of your own and trace some of the linkages by which one item called up another.

2. In speaking of "stimulus words" and "response words" in connection with an association test, are we using the terms *stimulus* and *response* strictly according to the definitions of Chapter I?

3. Respond to the following list of words, (a) by saying the first word suggested by each (free association), (b) by saying the opposite

of each, and (c) by giving a synonym for each. Notice whether any of the controlled associations are immediate:

rapid
wealthy
numerous
distant
ancient

difficult
wicked
feeble
quiet
costly

4. Mention a word which is readily understood in context though having two or more very different meanings.

5. Is all "insight" (p. 242) entitled to be called inference?

6. Can anything be inferred from these two premises?

No X is Y;
No Z is X.

Use a diagram and see if it helps to clarify the matter.

7. Illustrate verification in the case of the hypothesis that forgetting can be partial, rather than either all or none (p. 278).

8. Deduce the consequences of the hypothesis that thought consists in inner speech, and show which of these consequences are verified and which not verified.

9. Give an animistic conception of the tendency of loose things to slide down hill, and also a naive matter-of-course conception of the same phenomenon.

10. Consider whether the "composite photography" process of reaching a general concept would be more apt to occur in everyday life than in the laboratory experiments described in the text.

CHAPTER XVIII. IMAGINATION

1. How does imagining differ from remembering and from reasoning?

2. Show that the element of make-believe is present in adult games such as cards and football.

3. In what ways is creative invention like children's play?

4. What probable connection can you see between day dreaming and worry on one side and introversion-extroversion on the other (p. 96)?

5. How does Freud's theory of dreams differ from the free association theory?

6. Summarize three theories of the motivation of dreams.

7. What doubts are raised in this chapter, and also on pp. 319–321, regarding the unconscious?

8. Bring together the various uses of the rule, "Try, rest, try again."

9. Distinguish between delusion, illusion and hallucination.

10. Compare these three: (a) empathy, (b) animistic conceptions of nature, (c) emotion according to the James-Lange theory.

11. What would you suppose to be the process by which a good speech is produced?

12. Show in case of a work of imagination that the parts determine the effect of the whole, as well as the whole that of the parts.

13. Which cortical areas may well be involved in imaginative activity?

14. Do the powers of reasoning and imagining probably develop by activity or by maturation?

INDEX

INDEX

Ability, 84
Abulia, 329–331
Accessory sense-apparatus, 391
Accuracy, perception, 444
Achievement, in school, 83–84; tests, 58–59
Acquired traits, 140
Acromegaly, 118
Action, liberating, 330–332
Activity, 4–5; and motive, 300–302; complex learning, 245; continual, 217; in progress, 13, 300; learned and unlearned, 223–224; nerve fiber, 183; perseverating, 275; play, 494–495; prenatal, 168–173; prepared, 325–326; purposive, 324–329; (special characteristics) 328–329; unlearned, 305
Adams, H. F., 455
Adaptation, 235; negative, 236; temperature sense, 393; visual, 364
Addison's disease, 117
Adjustment, 9–12, 326–328; breadth, 328–329; intensity, 328; novelty, 328; precision, 328
Adler, A., 124, 125, 126, 133, 502, 521
Adolescence, 65, 176
Adrenal glands, 115–117, 308, 349–350
Adrenin, 357
Adrian, E. D., 221
Advantage, factors of, 256, 425, 451, 459
Aërial perspective, 384
After-image, 26–27, 374–375
Age, chronological, 53, 61; curve, 64–68; educational, 59; mental, 52, 61–63
Agnosia, 213
Alertness, 56–57, 82, 282
All or none law, 183, 197
Allport, F. H., 106
Allport, G. W., 106, 297
Alpert, A., 259
Ambiguous figure, 432–435; staircase, 434
Amnesia, 282; shock, 273
Analysis, of concept, 484; of intelligence, 80
Anderson, J. E., 30
Anecdotes, 17
Anger, 310; organic state, 349
Animal drives, 301–305
Animal learning, 225–239, 242, 249–254, 485
Anthropomorphism, 225, 301
Aoki, S., 232, 259
Aphasia, 212
Appetite, 351
Apprehension span, 441
Apraxia, 212–213
Area, association, 212; auditory, 199; histological, 204; motor, 199, 208; olfactory, 199, 207; sensory, 199, 208; striata, 203, 219; visual, 199, 202–207
Aristotle's illusion, 447
Army intelligence tests, 56
Art, 314; appeal, 512–513; empathy, 513–515; imaginative, 511–515; schools, 519–520
Ascendance and submission, 99
Assertiveness, *see* Self assertion
Association, by contiguity, 256; controlled, 461–464; fibers, 195, 196; free, 459–461; by similarity, 484
Associative reaction, 326
Atrophy, 159, 165, 281
Attention, 418–421; factors in, 425; motor adjustment, 419–431; sustained, 435–436
Attitudes, 95–96
Auditory sensations, 405–412
Autistic thinking, 507–511
Automatic writing, 286
Autonomic nerves, 347–348
Avoiding reaction, 308

Axon, 182, 187, 188, 189, 192, 194, 195, 209

Bainbridge, F. A., 178
Baldwin, B. T., 85
Banister, H., 416
Behavior, 25, 154–156, 170
Bergson, H., 319
Bills, A. G., 456
Bimodality, 37, 98
Binet, A., 50, 51, 52, 84
Binet-Simon scale, 50–52, 82, 84, 152, 176
Binocular vision, 381–383, 435
Bird, C., 178
Birth, 169–171; order, 124
Blanchard, M. B., 85
Blatz, W. E., 359
Blend, 370, 400, 407, 410
Blindness, 204; color, 371
Blood pressure, emotion, 346
Bock, A. V., 178
Body build, 99
Book, W. F., 248, 259
Boreas, T., 279, 297
Boring, E. G., 30
Brain, 185; interbrain, 348; size, 83; stem, 185
Bray, C. W., 416
Breed, F. S., 179
Brightness, visual, 366
Brouwer, B., 221
Brown, W., 259, 444, 455
Bryan, W. L., 246, 259
Bucy, P. C., 221
Burkamp, W., 388
Burks, B. S., 157
Burnett, N. C., 416
Burt, C. L., 30, 85, 487
Burzlaff, W., 388
Buytendijk, F. J. J., 221

Cajal, S. R., 192, 209, 396
Calkins, M. W., 297
Cannon, W. B., 116, 134, 359
Canon, Lloyd Morgan's, 225
Carmichael, L., 178
Carr, H. A., 338, 359
Case history, 23–25, 131
Castle, W. E., 157
Center, nerve, 185–187
Cerebellum, 185–187, 191, 196, 203, 211
Cerebrum, 185–187, 193–213; lobes, 198–199
Chain reflex, 228
Chappell, M. N., 222
Chemique, 108
Chick, 172
Child behavior, 54, 68, 91, 101–103, 123–129, 148–150, 174–177, 243, 293, 308–312, 467, 479–483, 489–491
Child, C. M., 178
Childhood memories, 286
Chimpanzee, 242
Choice reaction, 325
Chromosomes, 136–138, 143, 160; sex, 151
Chronological age, 53, 61
Claparède, E., 521
Clemens, S. L., 131
Clinic, 23, 124
Clinical psychology, 23
Cobb, M. V., 85
Cochlea, 402–404
Code, group, 127–129
Coghill, G. E., 221
Cold spot, 391
Collins, J. E., 76
Color, blindness, 371; complementary, 368–370; mixing, 367; tone, 366, 370; vision, 373
Combination, law of, 422
Concepts, 479–487
Condition, 12; control of, 20
Conditioned response, 249–256, 309
Cones, 363–365
Conflict of motives, 315–319
Conrad, H. S., 67, 85
Consistency, 100–104, 107
Consolidation, learning, 273
Constancy of IQ, 60–64
Constant error, 442
Contiguity, 256, 266
Coördinated movement, 216
Corpus callosum, 195
Correlation, 40–47, 89; coefficient, 42, 45; diagram, 40; method, 46, 82, 89
Cortex, adrenal, 115, 117; cerebral, 194, 197, 204–213
Cortin, 115–117
Creative thought, 517
Cretin, 112
Crime, 74
Criticism, 509; self, 510
Crystal gazing, 286
Culler, E., 106, 416
Curiosity, 352

Curve, distribution, 65, 68; of forgetting, 278, 280; growth, 67; learning, 246, 248; retention, 278, 280

Dallenbach, K. M., 416
Danforth, C. H., 179
Darwin, C., 339, 340
Dashiell, J. F., 229, 259
Daydreams, 495–500
Decision, 316; arbitrary, 317; incubation, 316
Decussation, 187
Defense mechanisms, 317–319
Delayed reactions, 234
Deliberation, 316
Delinquency, 73
Dementia praecox, 99
Dendrites, 187, 190, 192
Depression, 100, 437
De Silva, H. R., 388
Development, 158; of activity, 166–177; of attention, 436; of concepts, 479–487; early, 136; emotional, 353; factors, 138; intelligence, 64, 176; locomotion, 173; mental, 63–68; nervous system, 218–221; of eye, 161; social, 176
Deviation, 33, 38
Diabetes, 110
Differentiation, 161–163
Dill, D. B., 178
Dimensions, 33; of feeling, 335; of personality, 89, 94–98, 101–103
Dissociation, 104
Distance receptors, 390
Distraction, 252, 323, 437–440
Distribution, curve, 34, 61, 98; of intelligence, 60; measurement, 38; of traits, 89
Dodge, R., 388
Donaldson, H. H., 221
Doubt, 473
Downey, J. E., 522
Drawing test, 53–55
Dreams, 500–507; Freud's theory, 505–506; motivation, 501–504; seeming reality, 501; stimulus, 501
Drives, animal, 301; maternal, 308; measurement, 302–304; sex, 307
Drowsiness, 351
DuBois, E. F., 133
Duff, J. F., 76
Dunlap, K., 259
Dunn, L. C., 157
Dye, J. A., 179

Ear, 402–405
Ebbinghaus, H., 297
Economy, memory, 266–270, 281
Edinger, L., 193
Educational age, 59
Effectors, 6
Effort, 322–324
Egocentric concept, 481–483; response, 461
Eidetic image, 288
Élan vital, 319
Embryo, 218–220; development, 136–138
Emerson, R. W., 70
Emotion, control, 340; definition, 338; development, 353; expression, 339–347
Empathy, 493, 513–515
Emulation, 312
End brush, 190
Endocrine glands, 110–122
Energy, 322–324; release of, 330–332
Environment, 22, 76, 360; and development, 138–140; and heredity, 135–137, 141–151; and individual, 3–6, 8; and personality, 122–130; of siblings, 147; pressure, 74
Equilibrium, 413, 495
Errors, 18; of observation, 440–444
Esthetics, 454, 512–514
Ewert, P. H., 388
Excitement, 350
Exercise, 223
Experiment, 19–22
Exploration, 227, 304, 310, 488
Expressive movements, 339–353
Exteroceptors, 390
Extrovert, 96
Eye, 187, 202–203, 376; development, 161; movements, 380; structure, 362

Facial expression, 342–344
Facilitation, 216, 462
Factors, group, 85; in personality, 108–134
Familiarity, 446
Fatigue, 351
Fear, conditioned, 254; motive, 308
Feeblemindedness, 71–73
Feeling, 334–338; dimensions, 335

Feleky, A., 341, 343, 359
Ferrall, S. C., 416
Fiber tracing, 203
Field, of attention, 420; of view, 202
Fields, P. E., 437
Fighting, 310
Figure and ground, 429–431
Filimonoff, I. N., 221
Fisher, S. C., 487
Fixation, learning, 273
Fletcher, H., 408, 409, 416
Flourens, M. J. P., 198, 202
Fluctuation of attention, 431
Foerster, O., 221
Foresight, 81
Forgetting, 278–283
Forgotten name, 283
Form board, 53
Foster, F., 179
Foster children, 149–151
Fovea, 362, 364–365, 380
Franz, S. I., 107, 200
Free association, 458–461
Freeman, F. N., 157
Frequency, in learning, 256, 459
Freud, S., 125, 126, 321, 332, 502, 505, 506, 507, 521
Fulton, J. F., 221
Functions, brain localization, 197

Galileo, 19
Gall, F. J., 197, 198
Galton, F., 31, 32, 33, 43, 48, 64
Gamble, E. A. M., 297
Gangs, 127
Garrett, H. E., 30, 48
Gates, A. I., 297
General and special ability, 84
Generalization, 483
Generosity error, 93
Genes, 136–138
Genetic method, 22–25
Genius, 70
Gesell, A., 179
Giant pyramid cells, 209
Gibson, J. J., 285, 297
Glands, 6, 110–122
Goal-set, 11, 235, 324
Gonads, 119
Goodenough, F. L., 30, 54, 77, 85, 332
Gould, A. G., 179
Graft experiment, 160
Gray, A. A., 416
Gray matter, 189–194
Gregariousness, 311, 494
Grief, 352
Grouping, 264, 425–429, 451
Group tests, 56–58
Growth, 158; curve, 64–68, 167; through activity, 163–165, 271

Habit, 306
Haggerty, M. E., 76
Hallucination, 289, 447
Halo effect, 93
Harter, N., 246, 259
Hartridge, H., 416
Hartshorne, H., 91, 106
Harvey, W., 474
Hate, 354
Head movement, 412–415
Healy, W., 134
Hearing, 401–412
Heart beat in emotion, 345
Hecht, S., 388
Heidbreder, E., 106
Helmholtz, H., 388, 403, 475
Hemianopsia, 204
Henning, H., 401, 416
Henry, T. R., 134
Heredity, 12, 22, 47, 76; and environment, 135–157
Hesitancy, 315
Hicks, V. C., 226, 259
Higher units, 245
Hildreth, G. H., 157
Hilgard, E. R., 259
Hollingworth, H. L., 297
Hollingworth, L. S., 85
Holmes, G., 221
Holzinger, K. J., 48
Honesty tests, 101–103
Honzik, C. H., 230, 231, 260
Hormone, 110–121
Hoskins, R. G., 134
Hovey, H. B., 456
Hsiao, H. H., 259
Huang, I., 487
Hudgins, C. V., 259
Hull, C. L., 48, 298
Hunger, 82
Hunter, W. S., 259
Hybrids, 141
Hypnosis, 105, 282, 286, 298
Hypothesis, 17, 24, 28, 159, 474, 486

Identification, 125
Idiot, 71

I/E ratio, 346
Illumination, 378
Illusion, 446–449
Image, after sensations, 374; eidetic, 288; memory, 286–289
Imagery, 31, 286–289
Imagination, 488–522
Imbecile, 71
Incubation, 518
Indecision, 315
Individual, 3, 29, 31; and environment, 3–6, 8; activities, 4; atypical, 32; development, 24, 158–179; differences, 31–48
Infancy, 171
Inference, 465–467; difficulties, 469
Inhibition, 216–217, 263, 283; retroactive, 274
Initiative, 332
Insects, instincts of, 305
Insight, 242–245
Instinct, 305
Insulin, 110
Integration, 105; areas, 212; chemical, 109; neural, 185
Intellect, 49
Intelligence, 49–86; analysis, 80; definition, 49; delinquency, 73; development, 176; genius, 70; geographical differences, 79; heredity-environment, 143; measurement, 50; occupation, 75; of races, 77–79; success, 68; tests, 50–59; test results, 59–68
Intelligence quotient, 52; constancy, 60–64
Introspection, 26–28
Introversion-extroversion, 96–99
Invention, 509–511, 515–520
IQ, *see* Intelligence quotient

Jacobsen, C. F., 221
Jacobson, E., 487
Jaensch, E. R., 297
James, W., 355, 356, 510
James-Lange theory of emotions, 355
Jealousy, 312, 498
Jones, E. E., 456
Jones, H. E., 67, 85, 134, 332
Jones, M. C., 332
Jost, A., 297
Joy, 352
Judge Baker Foundation, 30
Jung, C. G., 106, 506, 521

Kappers, C. U. A., 221
Katz, D., 388, 416
Kinesthesis, 395
Kirahara, H., 76
Klineberg, O., 86
Klüver, H., 297
Köhler, W., 259, 388, 433, 456
König, A., 368
Krechevsky, I., 487
Kretschmer, E., 99, 100, 106
Kubie, L. S., 170, 171, 179
Kuhlmann, F., 51, 77

Ladd, G. T., 219, 220, 222
Ladd-Franklin, C., 373, 374, 388
Landis, C., 359
Lange, C., 355, 356
Language and thought, 475–479
Lashley, K. S., 200, 202, 222
Laslett, H. R., 86
Laughter, 103, 352
Law of selection, 459
Lawrence, E. M., 157
Leacock, S. B., 134
Learning, 201, 221–260; animal, 225–226; complex, 245; curves, 246, 248; definition, 224; essentials, 256–258; insight, 242; memorizing, 262–266; of tools, 238; trial and error, 239–241; unintentional, 271–272; unlearning, 305–306
Leonard, W. E., 297
Libido, 125
Life of relation, 337, 358, 361
Likes and dislikes, 313
Lobe, cerebral, 199; frontal, 213
Localization, cortical, 197–213; sounds, 411–412
Locomotion, development, 173
Locomotor ataxia, 397
Logic and psychology, 466
Love, 319, 354
Lowenstein, E., 416
Lowes, J. L., 521
Lungs, maturation of, 159
Lying, 128, 490

Macfarlane, D. A., 259
MacLeod, R. B., 388
Make-believe, 489, 500
Maladjustments, 126
Manic-depressive insanity, 99, 437
Manipulation, 311, 488–491
Manual tests, 35
Mark Twain, 131–133

Martin, E. G., 222
Martin, H. N., 181, 222
Mass action, 201
Mastery impulse, *see* Self-assertion
Mastery motive, 311–313, 320; in daydreaming, 495–497; in dreams, 503; in novel-reading, 512; in play, 493
Maturation, 159–161; activity, 158–179; breathing, 223; nervous system, 218–221
May, M. A., 91, 106
Maze learning, 57, 226–230; human, 237–238; short cuts, 232–233
McDougall, W., 106
Mead, M., 134
Meaning, 452
Measurement, of distribution, 38; drives, 302–304; intelligence, 50–59; personality, 90–99
Memory, 261–298; definition, 261; economy, 281; grouping, 264; images, 286–289; memorizing, 262; nonsense syllables, 264; paired associates, 265; recitation, 267; repetition, 264, 268; span, immediate, 263; training, 294–297; whole or part, 270
Mendel, G., 141
Mental age, 52, 61–63; on drawing test, 55
Mental, deficiency, 71–73; hygiene, 95, 126; manipulation, 488; work, 463
Merry, G. M., 345, 359
Metabolism, 111, 113; of embryo, 218
Method, 16–30; case history, 23–25; correlation, 46; genetic, 22–25; obstruction, 302; statistical, 38–47
Milch, E. C., 222
Miles, W. R., 167, 179
Miles, W. R. and C. C., 65, 66, 86
Mill, J. S., 71
Mirror drawing, 240
Mirth, 352
Mnemonics, 296
Monsters, 142
Moods, 352
Morale, 331
Morgan, C. L., 259
Morgan, J. J. B., 333
Morgan, T. H., 157
Moron, 72
Morpurgo, B., 179
Motion pictures, 386
Motives, escape, 308; in conflict, 315–319; mastery, 311; maternal, 308; rejected, 317; sex, 306; social, 311; unconscious, 319–321; unlearned, 305, 314
Motivation, 299–333; daydreams, 496–498; dreams, 502–504; novel-reading, 512; play, 492–494; reasoning, 472–475
Motor areas, 198–200, 208–211
Movement, 217; skilled, 218; visual, 386–388; *see also* Learning and Maturation
Muhl, A. M., 297
Müller-Lyer illusion, 448, 450
Multiple personality, 104–106
Murphy, G., 297
Muscle, 160, 163, 168, 169, 210, 344; emotion, 347; thought, 478; sense, 395
Muscular tension, 440
Myxedema, 112, 114, 122

Nash, A., 76
Native characteristics, 140
Negative adaptation, 236, 423, 438
Nerve, 180; autonomic, 347; current, 183, 185; fibers, 182, 203; paths, 215–216
Nervous system, 180–222; as telephone, 185; cellular structure, 187–189; exercise, 219; maturation, 218
Neuron, 187, 196, 216
Neuron theory, 190
Neurosis, 95
Newcomb, T. M., 106
Newman, H. H., 157
Nissen, H., 304
Noise, 405
Norm, 52
Novel-reading, 512

Oberly, H. S., 456
Object color, 377–379
Observation, 25–29, 418–456; errors, 440–444
Obstruction method, 302
Occipital lobe, 206
Occupation, and intelligence, 75–77, 149
Odors, 401
Ogburn, W. F., 521
Olfactory, 188; area, 207; receptors, 400

Optic chiasm, 203
Organic needs, 307; sensation, 397; state, 347, 349–353
Organism, 28, 180
Organismic principle, 14, 15
Organization of individual, 162
Orientation, 9–12, 229, 237, 290
Orphanage children, 148
Ossicles, 402
Overcoming obstruction, 322–324
Overtones, 407–410

Pain, 393; spots, 392
Paine, A. B., 134
Paired associates, 265
Pancreas, 110
Paradoxical cold, sensation, 392
Paralysis, 505; extirpation, 211
Paramnesia, 292
Parathyroids, 114
Paterson, D. G., 106
Pattern forming, 258
Patterns, 211, 212, 247, 258, 265, 432, 452, 456, 465, 469, 470, 516, 521; brain, 197
Pavlov, I. P., 249, 250, 259
Pearson, K., 43, 44
Peckham, G. W. & E. G., 259
Perception, accuracy, 444; definition, 361, 389; esthetic, 454; factors, 425; non-visual, 415; object color, 377; social, 458; visual, 360–387
Performance tests, 53–56; personality, 91–92
Perseveration, 274
Personality, 88–134; body build, 99; consistency, 100; dimensions, 89; factors, 108–134; interaction of factors, 130; measurement, 90–99; multiple, 104–106; profile, 89; rating scales, 92–94; social factors, 122–130; treatment of, 126
Perspective, aërial, 384
Phrenology, 197
Physiological data, 28
Physiological limit, 246
Physiology of emotion, 345–353
Physique, 108
Piaget, J., 134, 487
Piano theory of hearing, 403
Piéron, H., 222, 297
Pike, F. H., 222
Pitch, 405, 406
Pituitary gland, 117–119
Place-set, 235
Plateau, 247
Play, 490–493
Poffenberger, A. T., 456
Poggendorf illusion, 449
Poincaré, H., 521
Poljak, S., 222
Posture, 211
Practice, 245–249; curve, 246
Pratt, K. C., 222
Prenatal activity, 168–173
Preparatory set, 326–328, 349, 447, 462
Prepared action, 325
Primary memory image, 288
Prince, M., 106
Prince, W. F., 106
Principles of psychology, 14–15
Problem solving, 81, 463, 472
Profile, personality, 89
Projection fibers, 195, 196
Proofreader's illusion, 446
Proprioceptors, 390
Protozoa, 389
Pseudophone, 412
Psychoanalysis, 282
Psychogalvanic reflex, 347
Psychology, aim, 3–15, 225; animal, 303–304; clinical, 24; definition, 3; methods, 16–30; physiological, 29; problems, 11; principles, 14; schools, 520; terminology, 29; tests, 33
Psychotherapy, 126
Puberty, 176
Punishment, 257, 275–277
Pupillary reflex, 255, 347, 364
Purkinje cell, 191
Puzzle learning, 238, 241
Pyle, W. H., 297
Pyramids, 207, 208, 209, 211

Questionnaire, 94–98

Races, intelligence, 77–79
Racial survivals, 339
Rating scales, personality, 92–94
Rationalization, 472
Rayner, R., 260
Reaction, delayed, 234; time, 325
Reading, 381, 442
Reasoning, 464–475; difficulties, 466–471; inference, 465; motivation, 472–475; syllogism, 466–469
Recall, 283–290, 460; and recognition, 262, 293; childhood experi-

ences, 285; interference, 283; partial, 284
Recency, 256, 271, 283, 316, 459
Receptors, 6, 390, 394–395; olfactory, 400; visual, 364
Recitation, 267
Recognition, 290–294; disorders, 292; errors, 292; partial, 291; theory, 293
Reduced cue, 290, 292, 452
Reflex, 214, 217; arc, 213–218; conditioned, 249–256; of effort, 322; salivary, 250
Regensburg, J., 134
Reliability, 46; of rating scale, 94; of testimony, 272
Repetition, 256, 264, 423; spaced, 268
Repression, 282, 317
Resistance, 74, 130, 312, 322; synaptic, 191
Respiration in emotion, 345
Response, 6–9, 12–14, 25, 236
Retention, 277–283
Retina, 363
Retinal rivalry, 383
Retroactive inhibition, 274
Revery, 458–459
Reward and punishment, 257, 275–277, 301
Richter, C. P., 333
Rivalry, 312
Rods and cones, 364
Role, 123; of child in home, 123; in gang, 127
Rossman, J., 522
Rowe, A. W., 134
Rubin, E., 433, 456
Ruger, H. A., 64, 86, 242, 259

Sanford, E. C., 432, 456
Saturation, 366, 368
Schneck, M. R., 48
School achievement, 68, 83
Schools, of art, 519; of psychology, 520
Schopenhauer, A., 319
Schwegler, R. A., 106
Schwesinger, G. C., 157
Scientific method, 16, 474
Selectivity, 391, 421
Self-assertion, 311, 492–497, 503, 512, 515; thwarted, 313
Self-criticism, 510
Semicircular canal, 403, 414
Sensation, 361, 389; auditory, 405–411; cutaneous, 392; dizzy, 414; gustatory, 398; kinesthetic, 395; olfactory, 401; organic, 397; visual, 365–376
Sense organ, 389–391
Senses, 169, 360, 389
Sensory areas, 198–200, 203, 208
Sentiment, 354
Set, 9–13, 427; in anger, 350; in attention, 419; in controlled association, 462; in feeling, 337; for illumination, 379; for locality, 235; preparatory, 326–328, 447; for situation, 235
Seward, G. H., 297
Sex behavior, 120; differences, 151–154; maturity, 176; motive, 307–308, 318, 321
Shaw, C. R., 86, 134
Shell shock, 504
Shepard, J. F., 179, 259
Sherman, M., 134
Sherrington, C. S., 355, 359
Shifting, law of, 422; attention, 431; perception, 432–435
Shirley, M. M., 179
Shock amnesia, 273
Shut-in personality, 100
Siblings, 143, 144, 147
Sight, 360–387
Signs, 452
Similarity, association by, 483
Simple reaction, 325
Sinnott, E. W., 157
Sirkin, M., 76
Situation-set, 11, 235, 256, 337, 379, 380, 387
"Sixth sense," 395
Size-weight illusion, 447
Skaggs, E. B., 297
Skill, 245–249, 311, 489
Skin receptors, 394; senses, 391–395
Slawson, J., 86, 106
Sleep, 82, 280
Smell, 400
Smoke, K. L., 487
Snoddy, G. S., 240, 259
Snyder, J. C., 297
Sociability, 311, 494
Social development, 176; factors in invention, 518–520; in personality, 122–130; motive, 311; perception, 453; status and IQ, 149
Somesthetic area, 199, 208, 213

Southall, J. P. C., 388
Space perception, 379, 382–386, 411
Spaced repetition in learning, 268
Spalding, D. A., 179
Span of apprehension, 441; of memory, 263
Spearman, C., 84, 85, 86
Spectrum, 368
Speech, 175; centers, 212; sounds, 408
Spemann, H., 179
Spinal cord, 185
Spite, 506
Spots, sensitive, 391
Springs of action, 314, 321
Standard deviation, 38
Starr, M. A., 195
Statistical method, 38–47
Stepanow, G., 522
Stereoscope, 382
Sterzinger, O., 456
Stevanovic, B. P., 487
Stimulus, 6, 183, 325; and motive, 299; conditioned, 252; distracting, 252; internal, 7; of dream, 501; of recall, 290; sense, 365, 393, 396, 398, 401, 405, 413
Stockard, C. D., 157
Stoessiger, B., 64, 86
Stone, C. P., 259, 333
Störring, G., 487
Story-telling, 490
Strangeness, feeling of, 293
Stratton, G. M., 388, 411
Streeter, G. L., 220
Structure, 12, 13, 166; brain, 221; learning, 224; postulated, 224
Style, of life, 129
Subconscious mind, 518
Subjective phenomena, 27
Sublimation, 317–319
Success and intelligence, 68
Suggestion, 298
Superiority, 77
Surprise, 351
Sustained attention, 435
Syllogism, 466–472
Symbol, 476, 505
Symonds, P. M., 107
Sympathetic nerves, 348
Synapse, 190
Synesthesia, 289

Tactile path, 208
Taste, 397–400
Taussig, F. W., 522
Temperament, 108
Temperature sense, 391–394
Tendon spindle, 396
Terman, L. M., 51, 86
Terminology, 29
Test, 33; achievement, 58; controlled association, 461; drawing, 53–55; free association, 460; group, 56–58; intelligence, 50–59; manual, 35; maze, 57; performance, 53–56; personality, 91
Testimony, 272, 292, 346, 443
Thalamus, 195, 207–208, 348
Theelin, 119
Thinking, 457–487
Thirst, 306, 351
Thompson, H., 179
Thomson, G., 76
Thorndike, E. L., 86, 260, 298
Thorson, A. M., 487
Thought, language, 475–479; muscles, 478
Thrasher, F. M., 134
Thurstone, L. L. & T. G., 107
Thyroid gland, 111–114
Thyroxin, 112
Tilney, F., 170, 171, 179
Timbre, 406–408
Timme, W., 134
Tinklepaugh, O. L., 260
Tolman, E. C., 230, 231, 260
Tones, 405–408
Tongue, 399
Touch, 391–395
Toys, 490
Traits, 88, 98; consistency, 100–104; native vs. acquired, 140
Transfer, 295
Trial and error learning, 239–241
Troland, L. T., 333
Twilight vision, 365
Twitmyer, E. M., 260
Tympanic membrane, 402
Type, 32; constitutional, 99
Twins, 143; fraternal, 144; identical, 145–147, 177

Unconscious, 505–507; wishes and motive, 321
Uniformities of behavior, 154–156
Unlearned motives, 305–314
Upton, M., 416

Vacillation, 315
Validity, 46

van Ormer, E., 280, 298
Variability, 38, 444
Variable error, 443
Variables. 19
Vestibule of the ear, 402
Vision, 202–203, 360–388; erect, 385
Visual area, 202–207; contrast, 375; movement, 386–388; perception, 376–388; receptors, 364; size and shape, 379; sensation, 360–376
Vocal expression, 344
Voice, 175, 408
Von Spee, 219

Wada, T., 86
Walking, 174
Wallas, G., 522
Warden, C. J., 260, 303, 304, 333
Warmth spots, 392
Washburn, R. W., 107
Watson, J. B., 227, 238, 260
Weber, H., 456
Weber's law, 445
Weight, perception of, 396, 444
Wendt, G. R., 260
Wertheimer, M., 388, 428, 456
Wever, E. G., 416
Whipple, G. M., 48
Whole vs. part learning, 270, 282
Wiley, L. E., 222
Wilkins, M. C., 487
Wilkinson, G., 417
Will, 329–332; to learn, 271–273; to live, 319–321
Wingfield, A. H., 157
Wish fulfillment in dreams, 503
"Wolf children," 22
Woodworth, R. S., 219, 220, 222, 522
Worry, 498–500
Wundt, W., 335

Yerkes, R. M., 260
Yoshii, U., 417
Young, P. T., 412, 417
Young-Helmholtz theory, 373, 388

Zeigarnik, B., 298
Zoellner illusion, 450

Printed by Jarrold & Sons Ltd. Norwich

METHUEN'S
GENERAL LITERATURE

A SELECTION OF

MESSRS. METHUEN'S PUBLICATIONS

This Catalogue contains only a selection of the more important books published by Messrs. Methuen. A complete catalogue of their publications may be obtained on application.

ABRAHAM (G. D.)
MODERN MOUNTAINEERING
Illustrated. *7s. 6d. net.*

ARMSTRONG (Anthony) ('A. A.' of Punch)
WARRIORS AT EASE
WARRIORS STILL AT EASE
SELECTED WARRIORS
PERCIVAL AND I
PERCIVAL AT PLAY
APPLE AND PERCIVAL
ME AND FRANCES
HOW TO DO IT
BRITISHER ON BROADWAY
WHILE YOU WAIT
Each 3s. 6d. net.
LIVESTOCK IN BARRACKS
Illustrated by E. H. SHEPARD.
3s. 6d. net.
EASY WARRIORS
Illustrated by G. L. STAMPA.
5s. net.
YESTERDAILIES. Illustrated.
3s. 6d. net.

BALFOUR (Sir Graham)
THE LIFE OF ROBERT LOUIS STEVENSON *10s. 6d. net.*
Also, *3s. 6d. net.*

BARKER (Ernest)
NATIONAL CHARACTER
10s. 6d. net.
GREEK POLITICAL THEORY
14s. net.
CHURCH, STATE AND STUDY
10s. 6d. net.

BELLOC (Hilaire)
PARIS *8s. 6d. net.*
THE PYRENEES *8s. 6d. net.*

BELLOC (Hilaire)—*continued*
MARIE ANTOINETTE *18s. net.*
A HISTORY OF ENGLAND
In 7 Vols. Vols. I, II, III and IV
Each 15s. net.

BINNS (L. Elliott), D.D.
THE DECLINE AND FALL OF THE MEDIEVAL PAPACY. *16s. net.*

BIRMINGHAM (George A.)
A WAYFARER IN HUNGARY
Illustrated. *8s. 6d. net.*
SPILLIKINS: ESSAYS *3s. 6d. net.*
SHIPS AND SEALING-WAX: ESSAYS
3s. 6d. net.
CAN I BE A CHRISTIAN? *1s. net.*

CASTLEROSSE (Viscount)
VALENTINE'S DAYS
Illustrated. *12s. 6d. net.*

CHALMERS (Patrick R.)
KENNETH GRAHAME: LIFE, LETTERS AND UNPUBLISHED WORK
Illustrated. *10s. 6d.* net.

CHARLTON (Moyra)
PATCH: THE STORY OF A MONGREL
Illustrated by G. D. ARMOUR.
2s. 6d. net.
THE MIDNIGHT STEEPLECHASE
Illustrated by GILBERT HOLIDAY.
5s. net.

CHESTERTON (G. K.)
COLLECTED POEMS *7s. 6d. net.*
ALL I SURVEY *6s. net.*
THE BALLAD OF THE WHITE HORSE
3s. 6d. net.
Also illustrated by ROBERT AUSTIN. *12s. 6d. net.*

CHESTERTON (G. K.)—*continued*
All is Grist
Charles Dickens
Come to Think of It . . .
Generally Speaking
All Things Considered
Tremendous Trifles
Fancies versus Fads
Alarms and Discursions
A Miscellany of Men
The Uses of Diversity
The Outline of Sanity
The Flying Inn
Each 3*s*. 6*d*. *net*.
Wine, Water and Song 1*s*. 6*d*. *net*.

CURLE (J. H.)
The Shadow-Show 6*s*. *net*.
Also, 3*s*. 6*d*. *net*.
This World of Ours 6*s*. *net*.
To-day and To-morrow 6*s*. *net*.
This World First 6*s*. *net*.

DUGDALE (E. T. S.)
German Diplomatic Documents, 1871–1914
In 4 vols. Vol. I, 1871–90. Vol. II, 1891–8. Vol. III, 1898–1910. Vol. IV, 1911–14.
Each £1 1*s*. *net*.

EDWARDES (Tickner)
The Lore of the Honey-Bee
Illustrated. 7*s*. 6*d*. and 3*s*. 6*d*. *net*.
Bee-Keeping for All
Illustrated. 3*s*. 6*d*. *net*.
The Bee-Master of Warrilow
Illustrated. 7*s*. 6*d*. *net*.
Bee-Keeping Do's and Don'ts
2*s*. 6*d*. *net*.
Lift-Luck on Southern Roads
5*s*. *net*.

EINSTEIN (Albert)
Relativity: The Special and General Theory 5*s*. *net*.
Sidelights on Relativity
3*s*. 6*d*. *net*.
The Meaning of Relativity
5*s* *net*.
The Brownian Movement
5*s*. *net*.

EISLER (Robert)
The Messiah Jesus and John the Baptist
Illustrated. £2 2*s*. *net*.

EWING (A. C.)
Idealism 21*s*. *net*.

FIELD (G. C.)
Moral Theory 6*s*. *net*.
Plato and His Contemporaries
12*s*. 6*d*. *net*.
Prejudice and Impartiality
2*s*. 6*d*. *net*.

FINER (H.)
The Theory and Practice of Modern Government 2 vols.
£2 2*s*. *net*.
English Local Government
£1 1*s*. *net*.

FYLEMAN (Rose)
Happy Families
Fairies and Chimneys
The Fairy Green
The Fairy Flute *Each* 2*s*. *net*
The Rainbow Cat
Eight Little Plays for Children
Forty Good-night Tales
Forty Good-morning Tales
Seven Little Plays for Children
Twenty Tea-Time Tales
Each 3*s*. 6*d*. *net*.
The Blue Rhyme Book
Illustrated. 3*s*. 6*d*. *net*.
The Easter Hare
Illustrated. 3*s*. 6*d*. *net*.
Fifty-one New Nursery Rhymes
Illustrated by Dorothy Burroughes. 6*s*. *net*
The Strange Adventures of Captain Marwhopple
Illustrated. 3*s*. 6*d*. *net*.

GIBBON (Edward)
The Decline and Fall of the Roman Empire
With Notes, Appendixes and Maps, by J. B. Bury. Illustrated. 7 vols. 15*s*. *net* each volume. Also, unillustrated, 7*s*. 6*d*. *net* each volume.

GLOVER (T. R.)
Virgil
The Conflict of Religions in the Early Roman Empire
Poets and Puritans
Each 10*s*. 6*d*. *net*.
From Pericles to Philip
12*s*. 6*d*. *net*.

GRAHAME (Kenneth)
THE WIND IN THE WILLOWS
7s. 6d. net and *5s. net.*
Also illustrated by ERNEST H. SHEPARD. *Cloth, 7s. 6d. net.*
Green Leather, 12s. 6d. net.
Pocket Edition, unillustrated.
Cloth, 3s. 6d. net.
Green Morocco, 7s. 6d. net.
THE KENNETH GRAHAME BOOK ('The Wind in the Willows', 'Dream Days' and 'The Golden Age' in one volume).
7s. 6d. net.
See also **Milne (A. A.)**

HALL (H. R.)
THE ANCIENT HISTORY OF THE NEAR EAST *£1 1s. net.*
THE CIVILIZATION OF GREECE IN THE BRONZE AGE *£1 10s. net.*

HEATON (Rose Henniker)
THE PERFECT HOSTESS
Decorated by A. E. TAYLOR.
7s. 6d. net. Gift Edition, *£1 1s. net.*
THE PERFECT SCHOOLGIRL
3s. 6d. net.

HEIDEN (Konrad)
A HISTORY OF NATIONAL SOCIALISM
15s. net.

HERBERT (A. P.)
HELEN *2s. 6d. net.*
TANTIVY TOWERS and DERBY DAY in one volume. Illustrated by Lady VIOLET BARING. *5s. net.*
Each, separately, unillustrated
2s. 6d. net.
HONEYBUBBLE & CO. *3s. 6d. net.*
MISLEADING CASES IN THE COMMON LAW *5s. net.*
MORE MISLEADING CASES *5s. net.*
STILL MORE MISLEADING CASES
5s. net.
THE WHEREFORE AND THE WHY
'TINKER, TAILOR . . .'
Each, illustrated by GEORGE MORROW. *2s. 6d. net.*
THE SECRET BATTLE *3s. 6d. net.*
THE HOUSE BY THE RIVER
3s. 6d. net.
'NO BOATS ON THE RIVER'
Illustrated. *5s. net*

HOLDSWORTH (Sir W. S.)
A HISTORY OF ENGLISH LAW
Nine Volumes. *£1 5s. net each.*
Index Volume by EDWARD POTTON.
£1 1s. net.

HUDSON (W. H.)
A SHEPHERD'S LIFE
Illustrated. *10s. 6d. net.*
Also unillustrated. *3s. 6d. net.*

HUTTON (Edward)
CITIES OF SICILY
Illustrated. *10s. 6d. net.*
MILAN AND LOMBARDY.
THE CITIES OF ROMAGNA AND THE MARCHES
SIENA AND SOUTHERN TUSCANY
NAPLES AND SOUTHERN ITALY
Illustrated. *Each 8s. 6d. net.*
A WAYFARER IN UNKNOWN TUSCANY
THE CITIES OF SPAIN
THE CITIES OF UMBRIA
COUNTRY WALKS ABOUT FLORENCE
ROME
FLORENCE AND NORTHERN TUSCANY
VENICE AND VENETIA
Illustrated. *Each 7s. 6d. net.*

INGE (W. R.), D.D., Dean of St. Paul's
CHRISTIAN MYSTICISM. With a New Preface. *7s. 6d. net.*

JOHNS (Rowland)
DOGS YOU'D LIKE TO MEET
LET DOGS DELIGHT
ALL SORTS OF DOGS
LET'S TALK OF DOGS
PUPPIES
LUCKY DOGS
Each, Illustrated, *3s. 6d. net.*
SO YOU LIKE DOGS !
Illustrated. *2s. 6d. net.*
THE ROWLAND JOHNS DOG BOOK.
Illustrated. *5s. net.*

'OUR FRIEND THE DOG' SERIES
Edited by ROWLAND JOHNS.
THE CAIRN
THE COCKER SPANIEL
THE FOX-TERRIER
THE PEKINGESE
THE AIREDALE
THE ALSATIAN
THE SCOTTISH TERRIER
THE CHOW-CHOW
THE IRISH SETTER
THE DALMATIAN
THE LABRADOR
THE SEALYHAM
THE DACHSHUND
THE BULLDOG
THE BULL-TERRIER
THE GREAT DANE
THE POMERANIAN
THE COLLIE
THE ENGLISH SPRINGER
Each 2s. 6d. net.

KIPLING (Rudyard)
BARRACK-ROOM BALLADS
THE SEVEN SEAS
THE FIVE NATIONS
DEPARTMENTAL DITTIES
THE YEARS BETWEEN
Four Editions of these famous volumes of poems are now published, viz. :—
Buckram, 7*s*. 6*d*. *net*.
Cloth, 6*s*. *net*. *Leather*, 7*s*. 6*d*. *net*.
Service Edition. Two volumes each book. 3*s*. *net* each vol.
A KIPLING ANTHOLOGY—VERSE
Leather, 7*s*. 6*d*. *net*.
Cloth, 6*s*. *net* and 3*s*. 6*d*. *net*.
TWENTY POEMS FROM RUDYARD KIPLING 1*s*. *net*.
A CHOICE OF SONGS 2*s*. *net*.
SELECTED POEMS 1*s*. *net*.

LAMB (Charles and Mary)
THE COMPLETE WORKS
Edited by E. V LUCAS. Six volumes. 6*s*. *net each*.
SELECTED LETTERS
Edited by G. T. CLAPTON. 3*s*. 6*d*. *net*.
THE CHARLES LAMB DAY-BOOK
Compiled by E. V. LUCAS. 6*s*. *net*.
THE LETTERS OF CHARLES LAMB
Edited by E. V. LUCAS. Two volumes. 6*s*. *net each*.
THE BEST OF LAMB
Edited by E. V. LUCAS. 2*s*. 6*d*. *net*.

LANKESTER (Sir Ray)
SCIENCE FROM AN EASY CHAIR
First Series
SCIENCE FROM AN EASY CHAIR
Second Series
GREAT AND SMALL THINGS
Each, Illustrated, 7*s*. 6*d*. *net*.
SECRETS OF EARTH AND SEA
Illustrated. 8*s*. 6*d*. *net*.

LENNHOFF (Eugen)
THE FREEMASONS 21*s*. *net*.

LINDRUM (Walter)
BILLIARDS. Illustrated. 2*s*. 6*d*. *net*.

LODGE (Sir Oliver)
MAN AND THE UNIVERSE
7*s*. 6*d*. *net* and 3*s*. 6*d*. *net*.
THE SURVIVAL OF MAN 7*s*. 6*d*. *net*.
RAYMOND 10*s*. 6*d*. *net*.
RAYMOND REVISED 6*s*. *net*.
MODERN PROBLEMS 3*s*. 6*d*. *net*.
REASON AND BELIEF 3*s*. 6*d*. *net*.
THE SUBSTANCE OF FAITH 2*s*. *net*.
RELATIVITY 1*s*. *net*.
CONVICTION OF SURVIVAL 2*s*. *net*.

LUCAS (E. V.), C.H.
READING, WRITING AND REMEMBERING 18*s*. *net*.
THE COLVINS AND THEIR FRIENDS
£1 1*s*. *net*.
THE LIFE OF CHARLES LAMB
2 Vols. £1 1*s*. *net*.
AT THE SHRINE OF ST. CHARLES
5*s*. *net*.
POST-BAG DIVERSIONS 7*s*. 6*d*. *net*.
VERMEER THE MAGICAL 5*s*. *net*.
A WANDERER IN ROME
A WANDERER IN HOLLAND
A WANDERER IN LONDON
LONDON REVISITED (Revised)
A WANDERER IN PARIS
A WANDERER IN FLORENCE
A WANDERER IN VENICE
Each 10*s*. 6*d*. *net*.
A WANDERER AMONG PICTURES
8*s*. 6*d*. *net*.
E. V. LUCAS'S LONDON £1 *net*.
THE OPEN ROAD 6*s*. *net*.
Also, illustrated by CLAUDE A. SHEPPERSON, A.R.W.S.
10*s*. 6*d*. *net*.
Also, India Paper.
Leather, 7*s*. 6*d*. *net*.
THE JOY OF LIFE 6*s*. *net*.
Leather Edition, 7*s*. 6*d*. *net*.
Also, India Paper.
Leather, 7*s*. 6*d*. *net*.
THE GENTLEST ART
THE SECOND POST
FIRESIDE AND SUNSHINE
CHARACTER AND COMEDY
GOOD COMPANY
ONE DAY AND ANOTHER
OLD LAMPS FOR NEW
LOITERER'S HARVEST
LUCK OF THE YEAR
EVENTS AND EMBROIDERIES
A FRONDED ISLE
A ROVER I WOULD BE
GIVING AND RECEIVING
HER INFINITE VARIETY
ENCOUNTERS AND DIVERSIONS
TURNING THINGS OVER
TRAVELLER'S LUCK
AT THE SIGN OF THE DOVE
VISIBILITY GOOD *Each* 3*s*. 6*d*. *net*.
LEMON VERBENA
SAUNTERER'S REWARDS
Each 6*s*. *net*.
FRENCH LEAVES
ENGLISH LEAVES
THE BARBER'S CLOCK *Each* 5*s*. *net*.
'THE MORE I SEE OF MEN . . .'

LUCAS (E. V.)—*continued*
OUT OF A CLEAR SKY
IF DOGS COULD WRITE
'. . . AND SUCH SMALL DEER'
Each 3*s*. 6*d*. *net*.
See also **Lamb (Charles).**

LYND (Robert)
THE COCKLESHELL 5*s*. *net*.
RAIN, RAIN, GO TO SPAIN
IT'S A FINE WORLD
THE GREEN MAN
THE PLEASURES OF IGNORANCE
THE GOLDFISH
THE LITTLE ANGEL
THE BLUE LION
THE PEAL OF BELLS
THE ORANGE TREE
THE MONEY-BOX *Each* 3*s*. 6*d*. *net*.
'YY.' An Anthology of essays by ROBERT LYND. Edited by EILEEN SQUIRE. 7*s*. 6*d*. *net*.

McDOUGALL (William)
AN INTRODUCTION TO SOCIAL PSYCHOLOGY 10*s*. 6*d*. *net*.
NATIONAL WELFARE AND NATIONAL DECAY 6*s*. *net*.
AN OUTLINE OF PSYCHOLOGY 10*s*. 6*d*. *net*.
AN OUTLINE OF ABNORMAL PSYCHOLOGY 15*s*. *net*.
BODY AND MIND 12*s*. 6*d*. *net*.
CHARACTER AND THE CONDUCT OF LIFE 10*s*. 6*d*. *net*.
MODERN MATERIALISM AND EMERGENT EVOLUTION 3*s*. 6*d*. *net*.
ETHICS AND SOME MODERN WORLD PROBLEMS 7*s*. 6*d*. *net*.
THE ENERGIES OF MEN 8*s*. 6*d*. *net*.
RELIGION AND THE SCIENCES OF LIFE 8*s*. 6*d*. *net*.

MAETERLINCK (Maurice)
THE BLUE BIRD 6*s*. *net*.
Also, illustrated by F. CAYLEY ROBINSON. 10*s*. 6*d*. *net*.
OUR ETERNITY 6*s*. *net*.
THE UNKNOWN GUEST 6*s*. *net*.
POEMS 5*s*. *net*.
THE WRACK OF THE STORM 6*s*. *net*.
THE BETROTHAL 6*s*. *net*.
MARY MAGDALENE 2*s*. *net*.

MARLOWE (Christopher)
THE WORKS. In 6 volumes.
General Editor, R. H. CASE.
THE LIFE OF MARLOWE and DIDO, QUEEN OF CARTHAGE 8*s*. 6*d*. *net*.
TAMBURLAINE, I AND II 10*s*. 6*d*. *net*.

MARLOWE (Christopher)—*cont*.
THE WORKS—*continued*
THE JEW OF MALTA and THE MASSACRE AT PARIS 10*s*. 6*d*. *net*.
POEMS 10*s*. 6*d*. *net*.
DOCTOR FAUSTUS 8*s*. 6*d*. *net*.
EDWARD II 8*s*. 6*d*. *net*.

MARTIN (William)
UNDERSTAND CHINA 7*s*. 6*d*. *net*.

MASEFIELD (John)
ON THE SPANISH MAIN 8*s*. 6*d*. *net*.
A SAILOR'S GARLAND 3*s*. 6*d*. *net*.
SEA LIFE IN NELSON'S TIME 7*s*. 6*d*. *net*.

METHUEN (Sir A.)
AN ANTHOLOGY OF MODERN VERSE
SHAKESPEARE TO HARDY: An Anthology of English Lyrics.
Each, Cloth, 6*s*. *net*.
Leather, 7*s*. 6*d*. *net*.

MILNE (A. A.)
TOAD OF TOAD HALL
A Play founded on Kenneth Grahame's 'The Wind in the Willows'. 5*s*. *net*.
THOSE WERE THE DAYS: Collected Stories 7*s*. 6*d*. *net*.
BY WAY OF INTRODUCTION
NOT THAT IT MATTERS
IF I MAY
THE SUNNY SIDE
THE RED HOUSE MYSTERY
ONCE A WEEK
THE HOLIDAY ROUND
THE DAY'S PLAY
MR. PIM PASSES BY
Each 3*s*. 6*d*. *net*.
WHEN WE WERE VERY YOUNG
WINNIE-THE-POOH
NOW WE ARE SIX
THE HOUSE AT POOH CORNER
Each illustrated by E. H. SHEPARD. 7*s*. 6*d*. *net*. *Leather*, 10*s*. 6*d*. *net*.
THE CHRISTOPHER ROBIN VERSES ('When We were Very Young' and 'Now We are Six' complete in one volume). Illustrated in colour and line by E. H. SHEPARD. 8*s*. 6*d*. *net*.
THE CHRISTOPHER ROBIN STORY BOOK
Illustrated by E. H. SHEPARD. 5*s*. *net*.
THE CHRISTOPHER ROBIN BIRTHDAY BOOK
Illustrated by E. H. SHEPARD. 3*s*. 6*d*. *net*.

MILNE (A. A.) and FRASER-SIMSON (H.)
Fourteen Songs from 'When We were Very Young' 7*s.* 6*d.* *net.*
Teddy Bear and Other Songs from 'When We were Very Young' 7*s.* 6*d.* *net.*
The King's Breakfast 3*s.* 6*d.* *net.*
Songs from 'Now We are Six' 7*s.* 6*d.* *net.*
More 'Very Young' Songs 7*s.* 6*d.* *net.*
The Hums of Pooh 7*s.* 6*d.* *net.*
In each case the words are by A. A. Milne, the music by H. Fraser-Simson, and the decorations by E. H. Shepard.

MITCHELL (Abe)
Down to Scratch 5*s.* *net.*

MORTON (H. V.)
A London Year
Illustrated, 6*s.* *net.*
The Heart of London 3*s.* 6*d.* *net.*
Also, with Scissor Cuts by L. Hummel. 6*s.* *net.*
The Spell of London
The Nights of London
Blue Days at Sea *Each* 3*s.* 6*d.* *net.*
In Search of England
The Call of England
In Search of Scotland
In Scotland Again
In Search of Ireland
In Search of Wales
Each, illustrated, 7*s.* 6*d.* *net.*

NOMA (Seiji)
The Nine Magazines of Kodansha: The Autobiography of a Japanese Publisher. Illustrated. 10*s.* 6*d.* *net.*

OMAN (Sir Charles)
Things I Have Seen 8*s.* 6*d.* *net.*
A History of the Art of War in the Middle Ages, A.D. 378–1485. 2 vols. Illustrated. £1 16*s.* *net.*
Studies in the Napoleonic Wars 8*s.* 6*d.* *net.*

PETRIE (Sir Flinders)
A History of Egypt
In 6 Volumes.
Vol. I. From the Ist to the XVIth Dynasty 12*s.* *net.*
Vol. II. The XVIIth and XVIIIth Dynasties 9*s.* *net.*
Vol. III. XIXth to XXXth Dynasties 12*s.* *net.*
Vol. IV. Egypt under the Ptolemaic Dynasty
By Edwyn Bevan. 15*s.* *net.*

PETRIE (Sir Flinders)—*continued*
Vol. V. Egypt under Roman Rule
By J. G. Milne. 12*s.* *net.*
Vol. VI. Egypt in the Middle Ages
By S. Lane Poole. 10*s.* *net.*

PHILLIPS (Sir Percival)
Far Vistas 12*s.* 6*d.* *net.*

POLLOCK (William)
The Cream of Cricket 5*s.* *net.*

QUIGLEY (H.) and GOLDIE (I.)
Housing and Slum Clearance in London 10*s.* 6*d.* *net.*

RAGLAN (Lord)
Jocasta's Crime 6*s.* *net.*
The Science of Peace 3*s.* 6*d.* *net.*

SELLAR (W. C.) and YEATMAN (R. J.)
1066 and All That
And Now All This
Horse Nonsense
Each illustrated by John Reynolds. 5*s.* *net.*

STEVENSON (R. L.)
The Letters Edited by Sir Sidney Colvin. 4 Vols. *Each* 6*s.* *net.*

STOCK (Vaughan)
The Life of Christ 6*s.* *net.*

SURTEES (R. S.)
Handley Cross
Mr. Sponge's Sporting Tour
Ask Mamma
Mr. Facey Romford's Hounds
Plain or Ringlets?
Hillingdon Hall
Each, illustrated, 7*s.* 6*d.* *net.*
Jorrocks's Jaunts and Jollities
Hawbuck Grange
Each, illustrated, 6*s.* *net.*

TAYLOR (A. E.)
Plato: The Man and His Work £1 1*s.* *net.*
Plato: Timæus and Critias 6*s.* *net.*
Elements of Metaphysics 12*s.* 6*d.* *net.*

TILDEN (William T.)
The Art of Lawn Tennis *Revised Edition.*
Singles and Doubles
Each, illustrated, 6*s.* *net.*
The Common Sense of Lawn Tennis
Match Play and the Spin of the Ball. *Each*, illustrated, 5*s.* *net.*

TILESTON (Mary W.)

Daily Strength for Daily Needs 3s. 6d. net.
India Paper. *Leather*, 6s. net.

UNDERHILL (Evelyn)

Mysticism *Revised Edition.* 15s. net.
The Life of the Spirit and the Life of To-day 7s. 6d. net.
Man and the Supernatural 3s. 6d. net.
The Golden Sequence
Paper boards, 3s. 6d. net; Cloth, 5s. net.
Mixed Pasture: Essays and Addresses 5s. net.
Concerning the Inner Life 2s. net.
The House of the Soul 2s. net.

VIEUCHANGE (Michel)

Smara: The Forbidden City
Illustrated. 8s. 6d. net.

WARD (A. C.)

Twentieth Century Literature 5s. net.
The Nineteen-Twenties 5s. net.
Landmarks in Western Literature 5s. net.
American Literature 7s. 6d. net.
What is this Life? 5s. net.
The Frolic and the Gentle: A Centenary Study of Charles Lamb 6s. net.

WILDE (Oscar)

Lord Arthur Savile's Crime and the Portrait of Mr. W. H. 6s. 6d. net.
The Duchess of Padua 3s. 6d. net.
Poems 6s. 6d. net.
Lady Windermere's Fan 6s. 6d. net
A Woman of No Importance 6s. 6d. net.
An Ideal Husband 6s. 6d. net.
The Importance of Being Earnest 6s. 6d. net.
A House of Pomegranates 6s. 6d. net.
Intentions 6s. 6d. net.
De Profundis and Prison Letters 6s. 6d. net.
Essays and Lectures 6s. 6d. net.
Salomé, A Florentine Tragedy, and La Sainte Courtisane 2s. 6d. net.
Selected Prose of Oscar Wilde 6s. 6d. net.
Art and Decoration 6s. 6d. net.
For Love of the King 5s. net.
Vera, or the Nihilists 6s. 6d. net.

WILLIAMSON (G. C.)

The Book of Famille Rose
Richly illustrated. £8 8s. net.

METHUEN'S COMPANIONS TO MODERN STUDIES

Spain. E. Allison Peers. 12s. 6d. net.
Germany. J. Bithell. 15s. net.
Italy. E. G. Gardner. 12s. 6d. net.
France. R. L. G. Ritchie. 12s. 6d. net

METHUEN'S HISTORY OF MEDIEVAL AND MODERN EUROPE

In 8 Vols. *Each* 16s. net.

I. 476 to 911. By J. H. Baxter.
II. 911 to 1198. By Z. N. Brooke.
III. 1198 to 1378. By C. W. Previté-Orton.
IV. 1378 to 1494. By W. T. Waugh.
V. 1494 to 1610. By A. J. Grant.
VI. 1610 to 1715. By E. R. Adair.
VII. 1715 to 1815. By W. F. Reddaway.
VIII. 1815 to 1923. By Sir J. A. R. Marriott.